PB82-128935

KENTUCKY UTILITIES COMPANY, HANCOCK COUNTY GENERATING STATION UNITS 1 AND 2: TECHNICAL APPENDIX, VOLUME II

Environmental Protection Agency
Atlanta, GA

Sep 81

U.S. Department of Commerce
National Technical Information Service
NTIS

PB82-128935

United States
Environmental Protection
Agency

Region 4
345 Courtland Street, NE
Atlanta, GA 30365

EPA 904/9-81-081 b
September 1981

Environmental Impact Statement

Draft

Kentucky Utilities Company
Hancock County
Generating Station
Units 1 & 2

Technical Appendix
Volume II

PRODUCED BY:
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

BIBLIOGRAPHIC DATA SHEET

1. Report No.
EPA 904/9-81-081 b

2.

3. Recipient's Accession No.
PB82 128935

4. Title and Subtitle
Kentucky Utilities Company, Hancock County, Generating Station, Units 1 & 2 Draft Environmental Impact Statement

5. Report Date
September 1981

6.

7. Author(s)
EIS Branch, EIS Preparation Section, S&A Division

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
EIS Branch
345 Courtland Street
Atlanta, GA 30365

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
Box 9

13. Type of Report & Period Covered
Draft EIS

14.

15. Supplementary Notes
Reproduced from best available copy.

16. Abstracts

Kentucky Utilities Company proposes to construct and operate two 650 MW capacity coal-fired electric generating plants adjacent to Ohio River mile 715 in northeast Hancock County, Kentucky. The EIS examines project alternatives, impacts and mitigative measures related to groundwater, air, surface water, ecological, and socioeconomic and cultural systems.

17. Key Words and Document Analysis. 17a. Descriptors
Kentucky
Utilities Company
Hancock County
groundwater
air
Ohio River

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

18. Availability Statement

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page)
UNCLASSIFIED

21. No. of Pages

22. Price

3.3 LAND

Land areas that will be directly affected by the proposed action are in Hancock, Hardin, and Breckinridge counties, Kentucky. Physiography and geology of these areas is described in Section 3.3.1. Sections 3.3.2, 3.3.3, and 3.3.4 describe soils, vegetation, and wildlife.

3.3.1 Physiography and Geology

The three Kentucky counties of the project area lie in two physiographic regions (Figure 3.3-1): the Western Coal Field (Hancock County) and the Mississippian Plateau (Breckinridge and Hardin counties). Elevations are lowest in the alluvial valley of the Ohio River and highest near the Dripping Springs Escarpment of the Mississippian Plateau. A geologic structure cross section of western to northern Kentucky (Figure 3.3-2) shows most of the project area to be in the Mississippian system, with Hancock and Breckinridge counties in the transitional zone between Mississippian and Pennsylvanian systems. Figure 3.3-3 shows a generalized geologic column that relates these geologic systems to other systems and to notable events and time scales before the present time (Longwell et al. 1969).

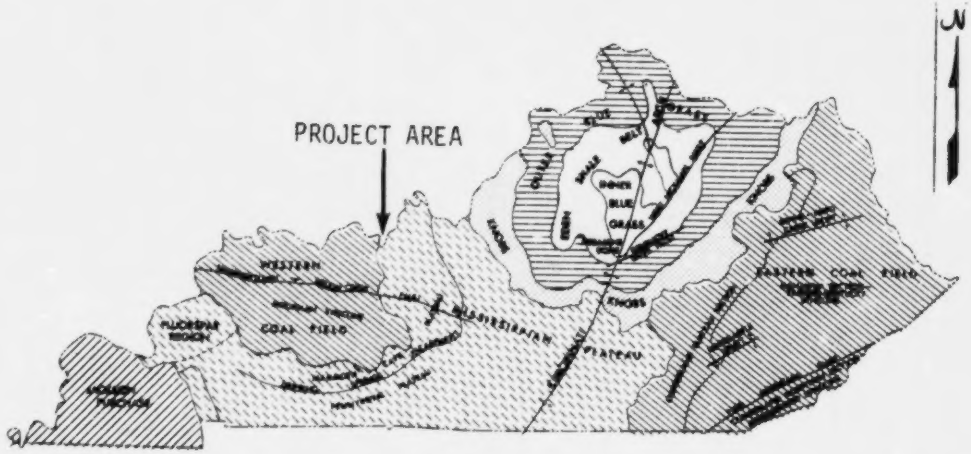
3.3.1.1 Physiographic Regions of the Project Area

Hancock County is the eastern-most county in the Western Coal Field of Kentucky. To the east of the western Coal Field is the Mammoth Cave Plateau, which is a part of the larger Mississippian Plateau. Separating the Western Coal Field from the Mammoth Cave Plateau is the Pottsville Escarpment, which is an eastward-facing cuesta deyeloped as a result of the resistant Caseyville sandstones and conglomerates. This escarpment starts in Hancock County at the Ohio River just to the west of the Hancock site. The perimeter of the Western Coal Field is hilly to rolling, except along the Ohio River where wide alluvial flats are present. Limestone outcrops along the Ohio River produce deep contrasting terrain effects. Cliff-forming sandstones along the Pottsville Escarpment contribute to a rugged aspect characterized by gorge-like valleys and steep, rocky cliffs (McGrain et al. 1970).

To the east of the Mammoth Cave Plateau is the Pennyroyal Plateau, which begins in western Hardin County and is another part of the Mississippian Plateau. These two plateaus are separated by the Dripping Springs Escarpment. In Breckinridge and Hardin counties, the smaller plateaus are characterized by gently rolling hills and meandering streams. The relief is much less pronounced than in eastern Hancock County (Kentucky Geologic Survey 1966).

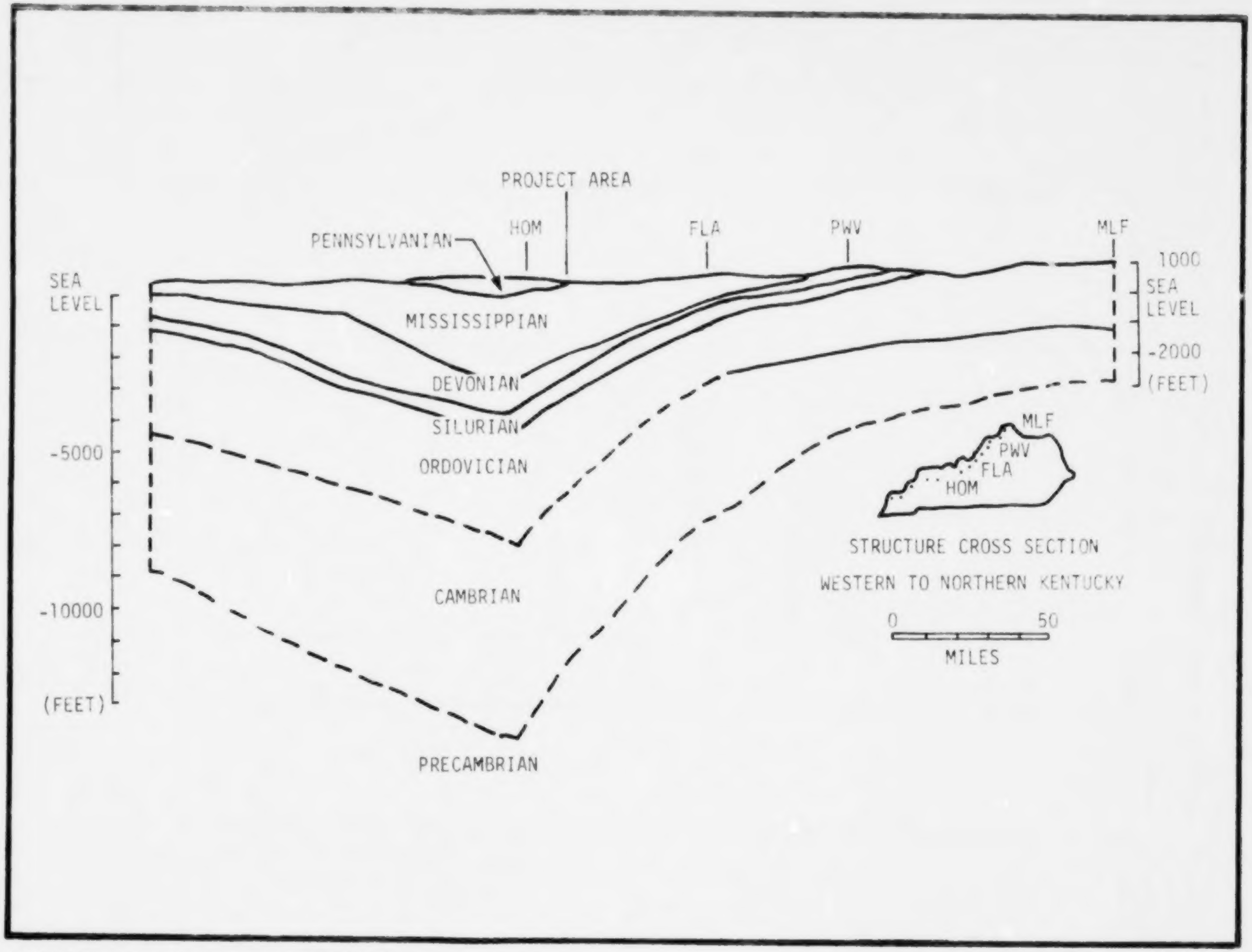
3.3.1.2 Major Topographic Features of the Project Area

The Ohio River and its tributaries within the project area have influenced the topography. The Ohio River ranges from 0.2 to 0.5 miles in width, while its alluvial plain reaches a maximum width of approximately 2.0 miles. A few alluvial terraces are present along its tributaries. Streams in the hilly, rolling uplands dissect sandstone, shale, and limestone plateaus. These hilly dissected lands are characterized by steep slopes, created by stream erosion and subsequent mass wasting. Some plateaus, ridges and uplands retain their loess caps, while erosion has exposed underlying bedrock in other areas (McGrain et al. 1970).


N
PROJECT AREA
WESTERN
COAL FIELD
FLUORSPAR REGION
MISSISSIPPIAN
PLATEAU
KNOBS
KNOBS
KNOBS
OUTER
BLUE
SHALE
BELT
INNER
BLUE
GRASS
EASTERN COAL FIELD

SOURCE: **Kentucky Geologic Survey (1966)**

Figure 3.3-1. Physiographic Regions of Kentucky

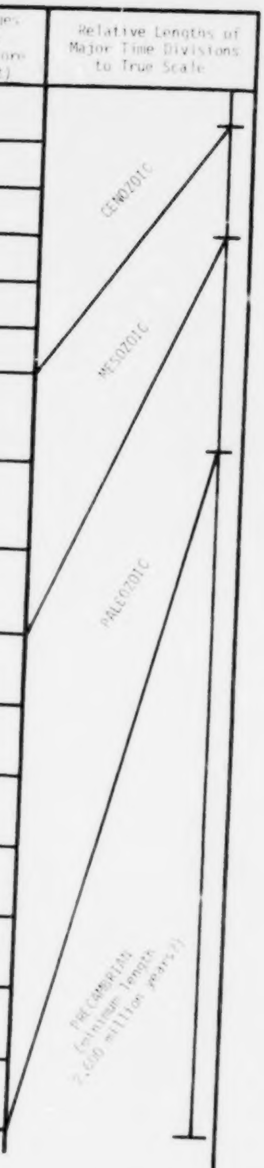

PROJECT AREA
PENNSYLVANIAN
HOM
FLA
PWV
MLF
SEA LEVEL
-5000
-10000
(FEET)
1000
SEA LEVEL
-2000
(FEET)
MISSISSIPPIAN
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
PRECAMBRIAN
MLF
PWV
FLA
HOM
STRUCTURE CROSS SECTION
WESTERN TO NORTHERN KENTUCKY
0
50
MILES

SOURCE: Bradley et al. (1967)

Figure 3.3-2. Structural Cross Section of Western to Northern Kentucky

THE GEOLOGIC COLUMN

Subdivisions Derived from Strata				Notable Events in Evolution of Organisms	Apparent Ages (millions of years before the present)
	Systems	Series	Stages		
CENOZOIC	Quaternary	(Recent) Pleistocene	More than twenty widely recognized	Man appears	2.5(?)
	Tertiary	Pliocene		Elephants, horses, large carnivores become dominant	13
		Miocene		Mammals diversify	25
		Oligocene		Grasses become abundant; grazing animals spread	36
		Eocene		Primitive horses appear	58
		Paleocene		Mammals develop rapidly	63
MESOZOIC	Cretaceous	Two or more series in each system	About thirty widely recognized	Dinosaurs become extinct; flowering plants appear Dinosaurs reach climax	135
	Jurassic			Birds appear	180
	Triassic			Primitive mammals appear; conifers and cycads become abundant Dinosaurs appear	230
PALEOZOIC	Permian		Many recognized	Reptiles spread; conifers develop	280
	Pennsylvanian (Upper Carboniferous)			Primitive reptiles appear; insects become abundant Coal-forming forests widespread	310
	Mississippian (Lower Carboniferous)			Fishes diversify	340
	Devonian			Amphibians, first known land vertebrates, appear Forests appear	400
	Silurian			Land plants and animals first recorded	430
	Ordovician			Primitive fishes, first known vertebrates, appear	500
	Cambrian			Marine invertebrate faunas become apparent	570
PRECAMBRIAN Complex assemblages of rocks, largely metamorphosed				Seas characterized by simple marine plants	


Relative Lengths of Major Time Divisions to True Scale
CENOZOIC
MESOZOIC
PALEOZOIC
PRECAMBRIAN (minimum length 2,600 million years?)

SOURCE: Longwell et al. (1969)

Figure 3.3-3. Generalized Geologic Column

The alluvial river plain provides a stark contrast with the hilly, rolling uplands of the area. Pool elevation of the Ohio River in the project area is 382.3 feet msl. Elevations within a mile of the river in western Breckinridge County rise to approximately 810 feet msl. The highest elevation in the general area of the Hancock and Breckinridge sites is approximately 835 feet msl, which is about 3 miles directly south of the Breckinridge site (see Figure 3.0-2).

Elevations along the Elizabethtown transmission corridor range from 425 feet msl near Cloverport, Kentucky to 905 feet msl near Dyer, Kentucky in Western Hardin County. This higher elevation is found along the Dripping Springs Escarpment separating the Mammoth Cave and Pennyroyal plateaus. Along most of the transmission corridor the elevations vary between 650 and 800 feet msl. These elevations change as the transmission corridor passes through hills and stream valleys. In general, the elevations are higher in the eastern portion of the project area and decline in a westward direction towards the Ohio River (USGS 1969).

3.3.1.3 Geologic Characteristics of the Project Area

3.3.1.3.1 Geologic Structure

The project area lies in the southeast portion of the Eastern Interior (Illinois) Basin (McGrain et al. 1970); the Cincinnati Arch lies to the east (Figure 3.3-1). A basin is a region where the crust of the earth is relatively thicker than other regions due to subsidence, sedimentary deposition, and similar activities, while arches are relatively thinner than surrounding regions due to uplifting, rifting, tectonic plate movements, and similar activities.

Geologic structure in the project area is essentially a homocline, with the dip of the strata being to the west. Regional structure is modified locally by a few faults and anticlinal folds (McGrain et al. 1970). The cross section in Figure 3.3-2 shows that the top of the Precambrian complex is approximately 10,000 feet below sea level in the project area, with increasing depth west of the project area. Cambrian sandstones are deposited over much of the region over the irregular Precambrian surface. The Ordovician strata comprise interbedded shale, limestone, dolomite and a few beds of sandstone and shale. The Silurian strata comprise limestone and dolomite, while the Devonian strata comprise limestone and shale.

3.3.1.3.2 Seismic Characteristics

Seismic characteristics of the project area were determined from the location and activity of major faults within the region and from seismic zone classification of the region based upon prior earthquake activity. The central midcontinent of the United States is a part of the North American craton, which is commonly regarded as having been a stable platform since Cambrian time (approximately 500 million years before the present). However, recent investigations, particularly seismicity studies, have revealed that areas near the confluence of the Ohio and Mississippi rivers, are structurally complex and tectonically active.

3.3.1.3.2.1 Major Faults

Evidence accumulated during the past decade indicates that the mid-continent area of the United States has been and is tectonically active, to the extent that tectonism must be considered in evaluating sites for structurally sensitive buildings and facilities. As indicated, the project area is in the Illinois Basin seismotectonic region, which is west of the Cincinnati Arch. The myriad of fault systems, which together form the 38th Parallel Lineament (Hinze et al. 1977), had their principal development in late Precambrian and early Paleozoic time (approximately 570 million years ago). This fault system continued to be active through the Paleozoic and perhaps into the Mesozoic and Cenozoic Eras (approximately 50 million years ago). The displacement along these faults was complex with strike-slip and vertical movements of several kilometers having been indicated. Figure 3.3-4 shows the project area with respect to regional tectonic features and the 38th Parallel Lineament fault system.

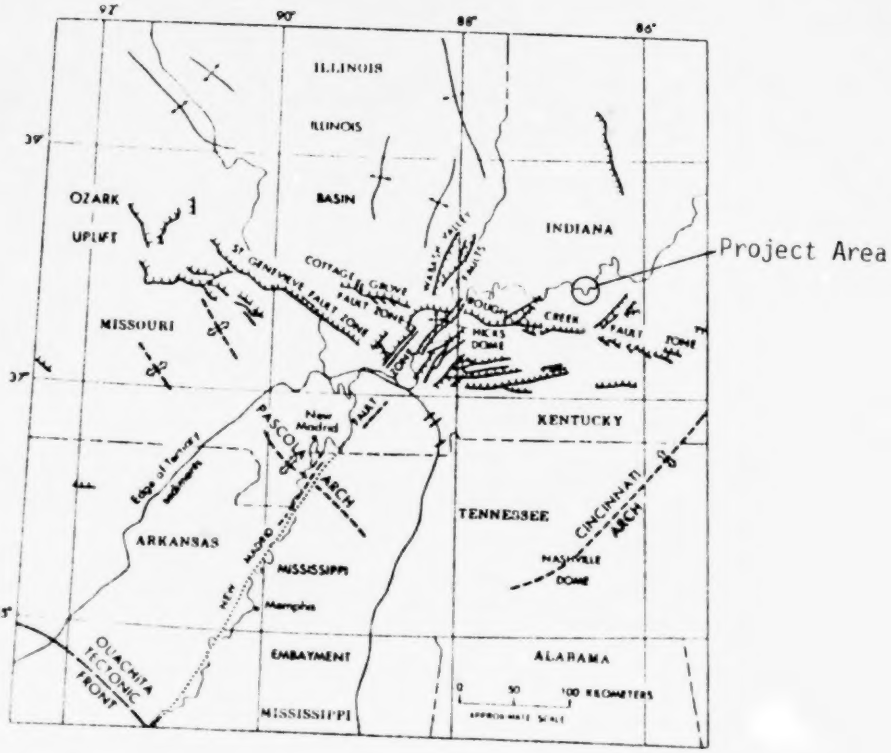
The most intense earthquake activity in the region has been centered in the New Madrid Seismic Zone in southeast Missouri and adjacent areas. The 38th Parallel Lineament fault system lies north of the New Madrid Seismic Zone. The most prominent fault system in the project area is the Rough Creek Fault Zone, which lies approximately 30 miles south of the sites and is a part of the 38th Parallel Lineament fault system. Fault patterns along the Rough Creek Fault Zone are generally complex. Structural displacement has affected Pennsylvanian age strata but not the Tertiary strata. Therefore, movement along this fault system is dated as post-Pennsylvanian and pre-Tertiary. Magnitude-recurrence for earthquakes in the central Mississipi Valley indicates a level of seismicity in which a given magnitude is about one tenth as freqent as an equivalent earthquake in active seismic zones in the western United States (Hinze et al. 1977).

3.3.1.3.2.2 Seismic Zone Classification

Seismic risk in an area can be quantified from the probability of occurrence of a given earthquake and resulting damage. The Modified Mercalli (MM) earthquake intensity scale and expected damage quantifies earthquake magnitude. The MM intensity scale is given in Table 3.3-1. The correlation between the Richter magnitude scale and the Mercalli intensity scale is:

Richter Magnitude	Mercalli Intensity
2	I-II
3	III
4	IV-V
5	VI-VII
6	VII-VIII
7	IX-X
8	XI

The 1976 Uniform Building Code Seismic Zone Map of the United States (Figure 3.3-5) places the Hancock and Breckinridge sites in Zone 2, which is indicative of moderate damage, corresponding to MM intensity VII (EPA Region IV 1978).



92°
90°
88°
86°
39°
37°
35°
ILLINOIS
ILLINOIS
BASIN
OZARK
UPLIFT
MISSOURI
ST. GENEVIEVE FAULT ZONE
COTTAGE GROVE FAULT ZONE
WABASH VALLEY FAULTS
INDIANA
Project Area
ROUGH CREEK FAULT ZONE
HICKS DOME
KENTUCKY
New Madrid
PASCOLA ARCH
FAULT
Edge of Tertiary sediments
ARKANSAS
TENNESSEE
CINCINNATI ARCH
NASHVILLE DOME
NEW MADRID
MISSISSIPPI
Memphis
EMBAYMENT
ALABAMA
OUACHITA TECTONIC FRONT
MISSISSIPPI
0
50
100 KILOMETERS
APPROXIMATE SCALE

SOURCE: Hinze et al. (1977)

Figure 3.3-4. Tectonic Map of the Region

Table 3.3-1. Earthquake Intensity Scale and Expected Damage

Scale	Expected Damage*
I	Not felt. Marginal and long-period effects of large earthquakes.
II	Felt by persons at rest, on upper floors, or favorably placed.
III	Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.
IV	Hanging objects swing. Vibration like passing of heavy trucks or sensation of a jolt like a heavy ball striking the walls. Standing motor cars rock; windows, dishes, doors rattle; glasses clink; crockery clashes. In the upper range of IV, wooden walls and frame creak.
V	Felt outdoors; direction estimated. Sleepers wakened; liquids disturbed and some spilled; small, unstable objects displaced or upset; doors swing, close, open; shutters, pictures move; pendulum clocks stop, start, change rate.
VI	Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware break; knickknacks, books, etc., off shelves; pictures off walls; furniture moves or overturns; weak plaster and masonry D crack; small bells ring (church, school); trees, bushes shake (visibly, or are heard to rustle).
VII	Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver; furniture breaks; masonry D, including cracks, damaged; weak chimneys break at roof line; plaster, loose bricks, stones, tiles, cornices (also unbraced parapets and architectural ornaments) fall; some cracks in masonry C; waves on ponds; water turbid with mud; small slides and caving in along sand or gravel banks; large bells ring; concrete irrigation ditches damaged.
VIII	Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Stucco and some masonry walls fall; chimneys, factory stacks, monuments, towers, elevated tanks twist, fall; frame houses move on foundations if not bolted down; loose panel walls are thrown out; decayed piling breaks; branches break from trees; flow or temperature of springs and wells changes; cracks in wet ground and on steep slopes.
IX	General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. General damage to foundations. Frame structures, if not bolted, shift off foundations; frames rack; serious damage to reservoirs. Underground pipes break; conspicuous cracks in ground. In alluviated areas, sand and mud ejected, earthquake fountains, sand craters.
X	Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides; water thrown on banks of canals, rivers, lakes, etc.; sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.
XI	Rails bent greatly. Underground pipelines completely out of service.
XII	Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

*Masonry A, B, C, D are specified by Richter as follows:

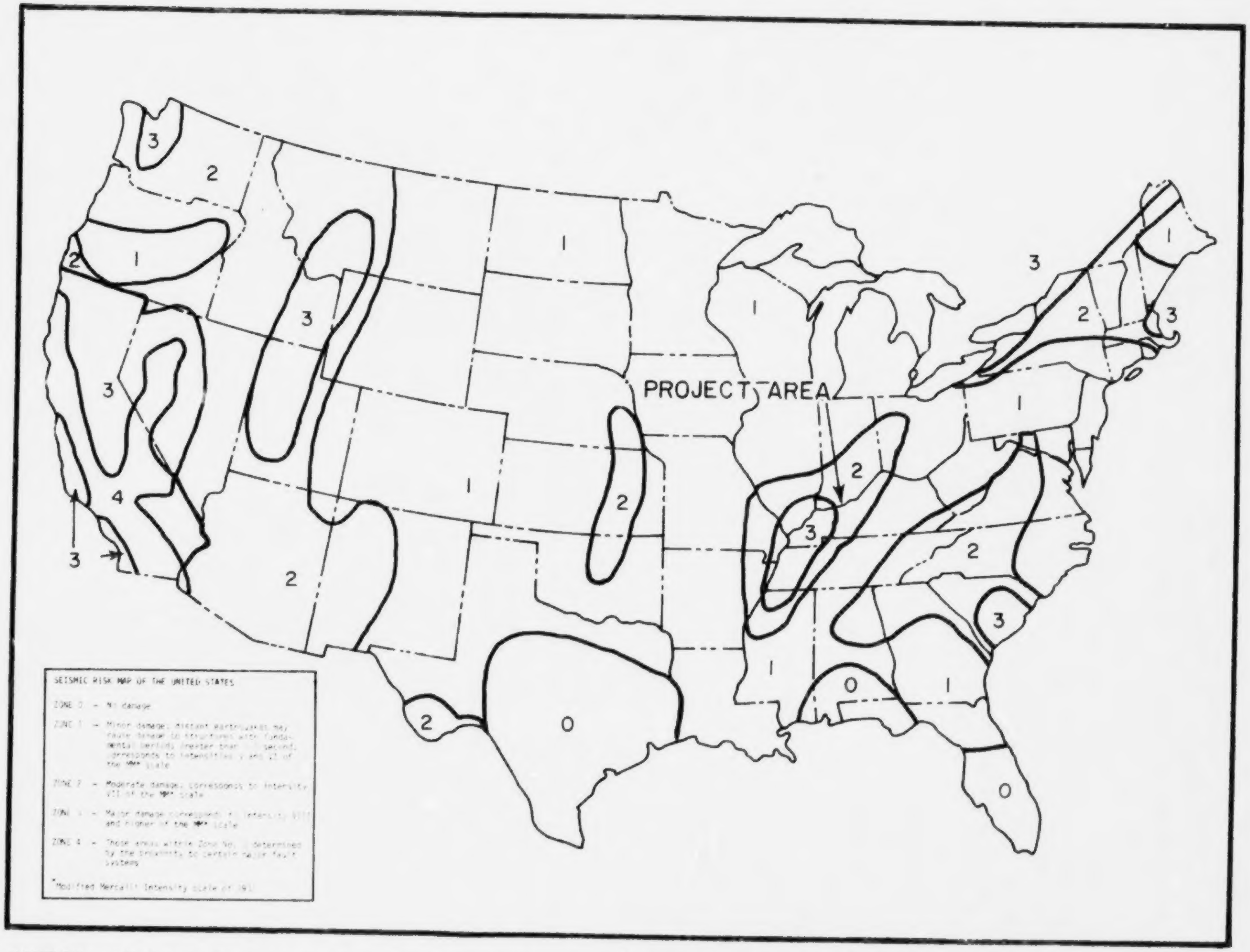
Masonry A – Good workmanship mortar and design; reinforced, especially laterally, and bound together by steel, concrete, etc.; designed to resist lateral forces.

Masonry B – Good workmanship and mortar; reinforced but not designed in detail to resist lateral forces.

Masonry C – Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but not reinforced or designed against horizontal forces.

Masonry D – Weak materials such as adobe; poor mortar; low standards of workmanship; weak horizontally.

Source: USGS (1979).


3
2
1
2
3
3
4
3
3
2
1
1
1
2
0
2
PROJECT AREA
1
2
3
3
2
3
1
0
1
0
1
3
2
3
SEISMIC RISK MAP OF THE UNITED STATES
ZONE 0 - No damage
ZONE 1 - Minor damage; distant earthquakes may cause damage to structures with fundamental periods greater than 1.0 second; corresponds to intensities V and VI of the MM* scale
ZONE 2 - Moderate damage; corresponds to intensity VII of the MM* scale
ZONE 3 - Major damage; corresponds to intensity VIII and higher of the MM* scale
ZONE 4 - Those areas within Zone No. 3 determined by the proximity to certain major fault systems
*Modified Mercalli Intensity Scale of 1931

SOURCE: United States Environmental Protection Agency Region IV (1978)

Figure 3.3-5. Seismic Risk Map of the United States

The United States Geological Survey has recently produced an earthquake hazard map (Figure 3.3-6) in which the contour lines represent the percent of gravity for horizontal seismic acceleration based on an earthquake return period of 500 years with a 90% probability of not being exceeded in 50 years. From this map, the Hancock and Breckinridge sites are estimated to experience a ground shaking of approximately 4% of gravity (Algermissen and Perkins 1976).

On July 27, 1980, an earthquake estimated at 5.1 Richter magnitude was centered at Maysville, Kentucky, southeast of Cincinnati, about 165 miles ENE of the sites. Prior to this earthquake, the largest tremor in northern Kentucky, which occurred in 1933, measured Richter magnitude 4.2. Seismic risk assessments of the region may be reevaluated because of the 1980 earthquake (The Hancock Clarion 1980; Science News 1980).

3.3.1.4 Hancock Site

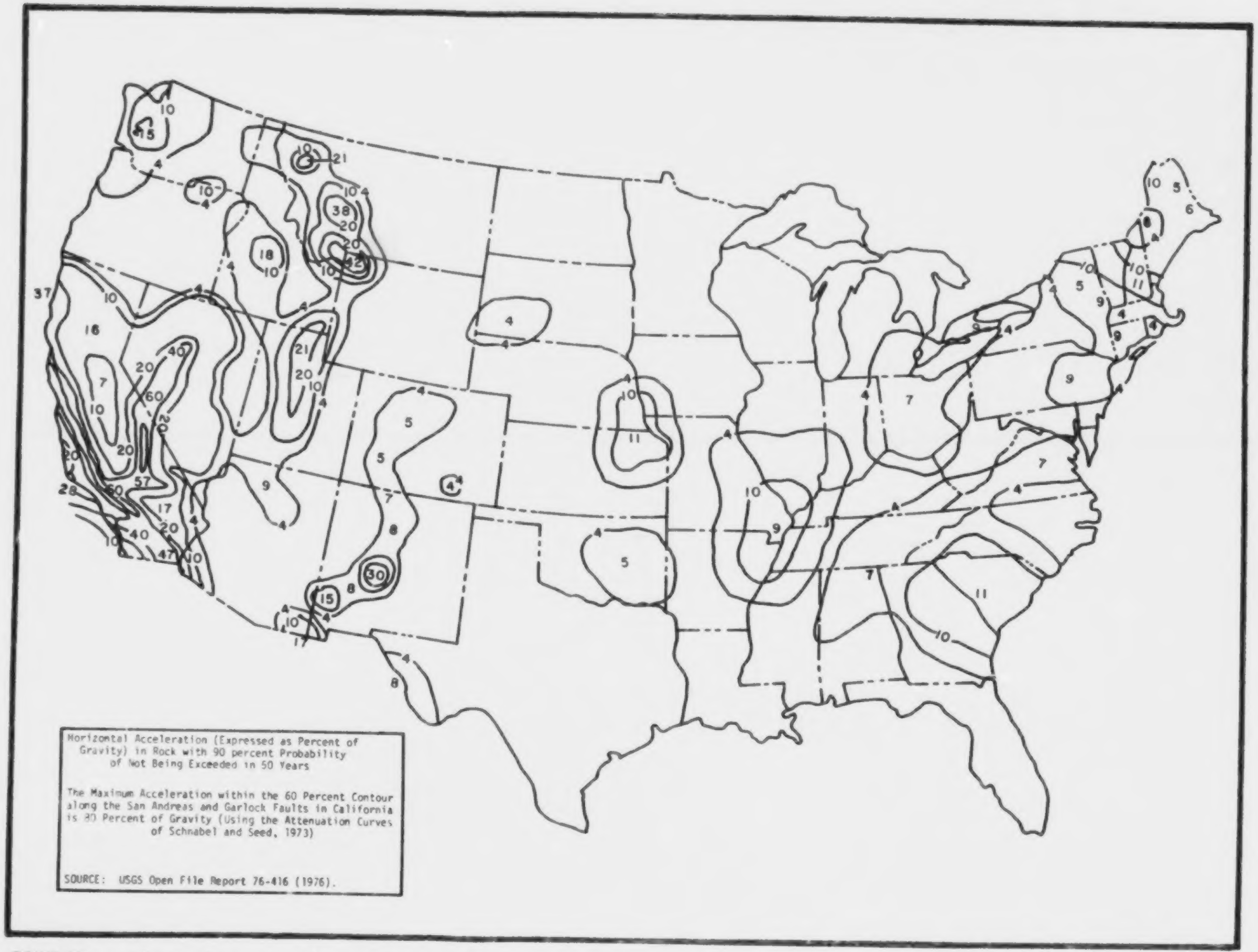
The Hancock site is located in a transition zone where wide, Ohio River alluvial flats intersect with rolling, hilly terrain. Figure 3.3-7 illustrates the geology of the Hancock site. The oldest exposed formation in Hancock County, the Glen Dean Limestone, outcrops for approximately 2 miles along the Ohio River. The Hancock site boundary is adjacent to the northern section of this outcrop. The northern portion of the site is alluvium with elevations ranging from 390 to 430 feet msl. The northeastern portion of the site contains terrace deposits of Pleistocene age at elevations of 400 to 450 feet msl. Two abandoned gravel pits are contained in the terrace deposits. Highest elevations on the site, up to 680 feet msl, are located in the southern portion. These elevations are underlain by the Caseyville conglomeratic sandstone of Pennsylvanian age. The Hancock site essentially surrounds Jeffry Cliff, which has about 100 feet of Caseyville Sandstone outcrop exposed to an elevation of about 700 feet msl. The remainder of the southern portion of the site, is underlain by the Buffalo Wallow Formation and the Tar Springs Formation (Kentucky Geologic Survey 1965a).

A generalized stratigraphic section of the geology of Hancock County is shown in Figure 3.3-8. In the northeastern portion of the county, including the Hancock site, the strata dip to the west, and the Pennsylvanian strata shown in the geologic column are not present.

The Hancock site has one concealed fault that extends southwesternly and lies approximately 2000 feet west of the highway 1406 boundary (Figure 3.3-9). In Hancock County, the fault extends from the Ohio River to near Goering in the central part of the county, with the downthrow on the western side of the fault (Kentucky Geologic Survey 1978).

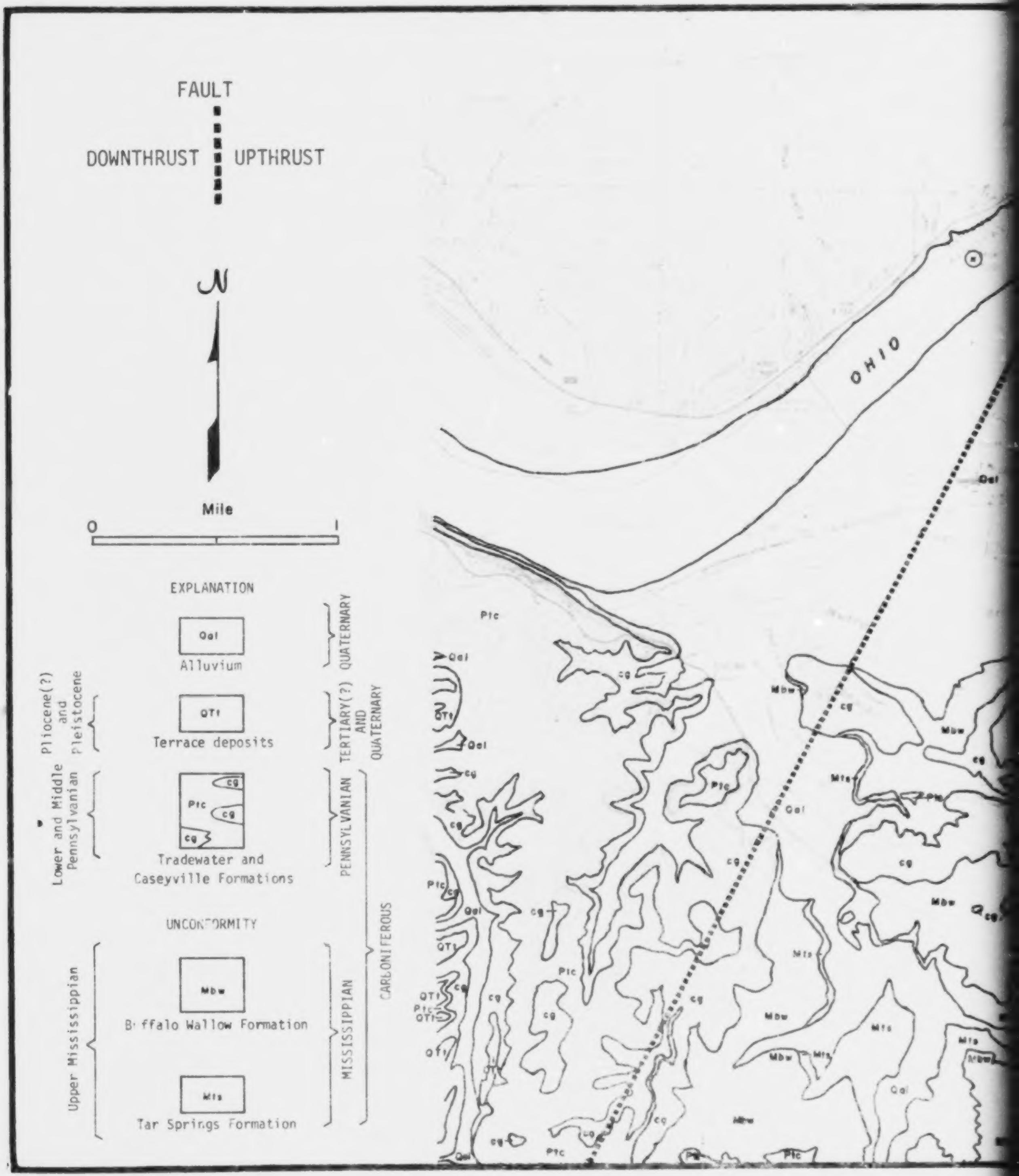
3.3.1.5 Breckinridge Site

Like the Hancock site, the Breckinridge site is located in a transition zone between the Ohio River alluvium and rolling, hilly upland terrain (Figure 3.3-10). The northwestern portion of the site is composed of alluvium and terrace deposits and ranges in elevation from 400 to 450 feet msl. Alluvium along Town Creek extends to the east central boundary of the site. The northeastern portion of the site ranges in elevation from 450 to 600 feet msl and is underlain by shale and sandstone members of the Tar Springs Formation,


Horizontal Acceleration (Expressed as Percent of Gravity) in Rock with 90 percent Probability of Not Being Exceeded in 50 Years
The Maximum Acceleration within the 60 Percent Contour along the San Andreas and Garlock Faults in California is 80 Percent of Gravity (Using the Attenuation Curves of Schnabel and Seed, 1973)
SOURCE: USGS Open File Report 76-416 (1976).

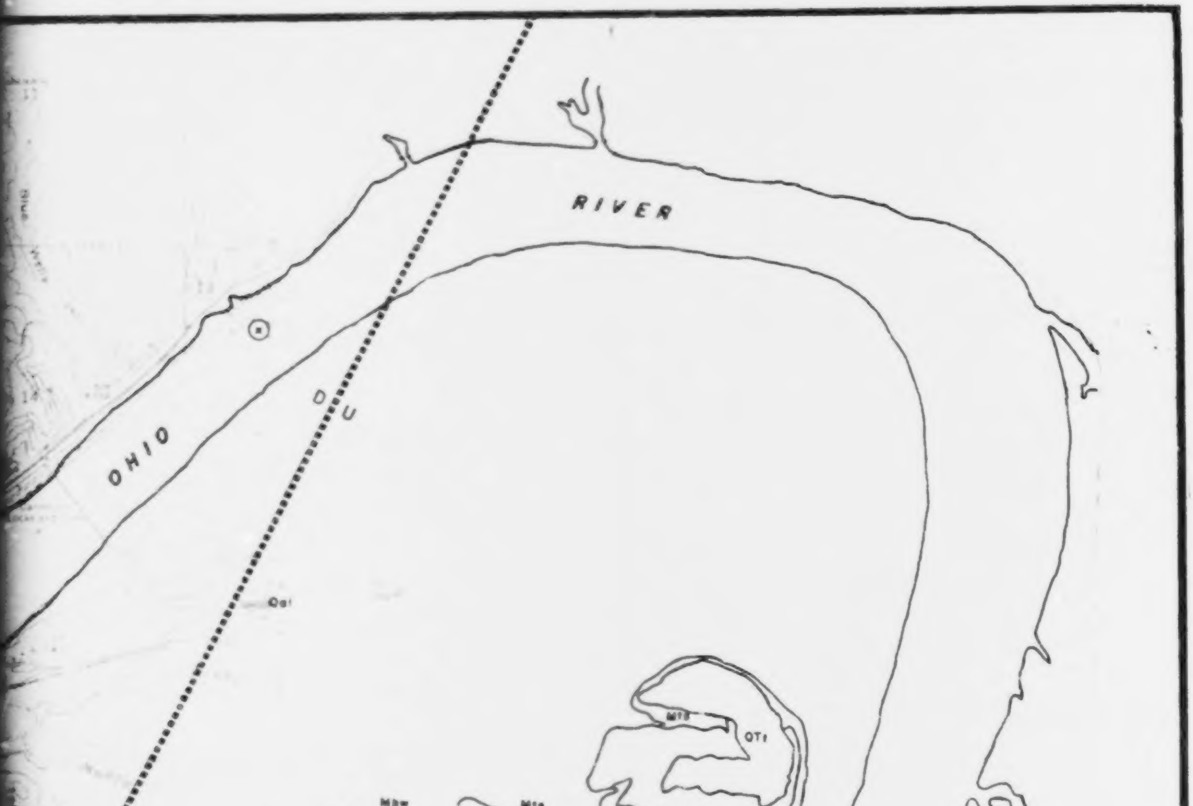
SOURCE: Algermissen and Perkins (1976)

Figure 3.3-6. Seismic Horizontal Acceleration Map


FAULT
DOWNTHRUST
UPTHRUST
N
Mile
0
1
EXPLANATION
Qal
Alluvium
QUATERNARY
Pliocene(?) and Pleistocene
QTt
Terrace deposits
TERTIARY(?) AND QUATERNARY
Lower and Middle Pennsylvanian
Ptc
cg
Tradewater and Caseyville Formations
PENNSYLVANIAN
UNCONFORMITY
CARBONIFEROUS
Upper Mississippian
Mbw
Buffalo Wallow Formation
MISSISSIPPIAN
Mts
Tar Springs Formation
OHIO

SOURCE: Kentucky Geological Survey (1956a)

Figure 3.3-7. Geology of the Hancock Site


RIVER
OHIO
D
U
Qal
Mts
QTt
Mbw
Mts
Mbw
Mts
Mbw
cg
Mbw
cg
cg
Qal
Mts
Ptc
Mts
Qal
Ptc
cg
Mbw
Mbw
cg
Mbw
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Mbw
Mts
Mts
Mts
Ptc
Mbw
Mts
Mts
Mbw
Qal
Qal
Mts
Mbw
Mbw
Mbw
Mbw
Ptc

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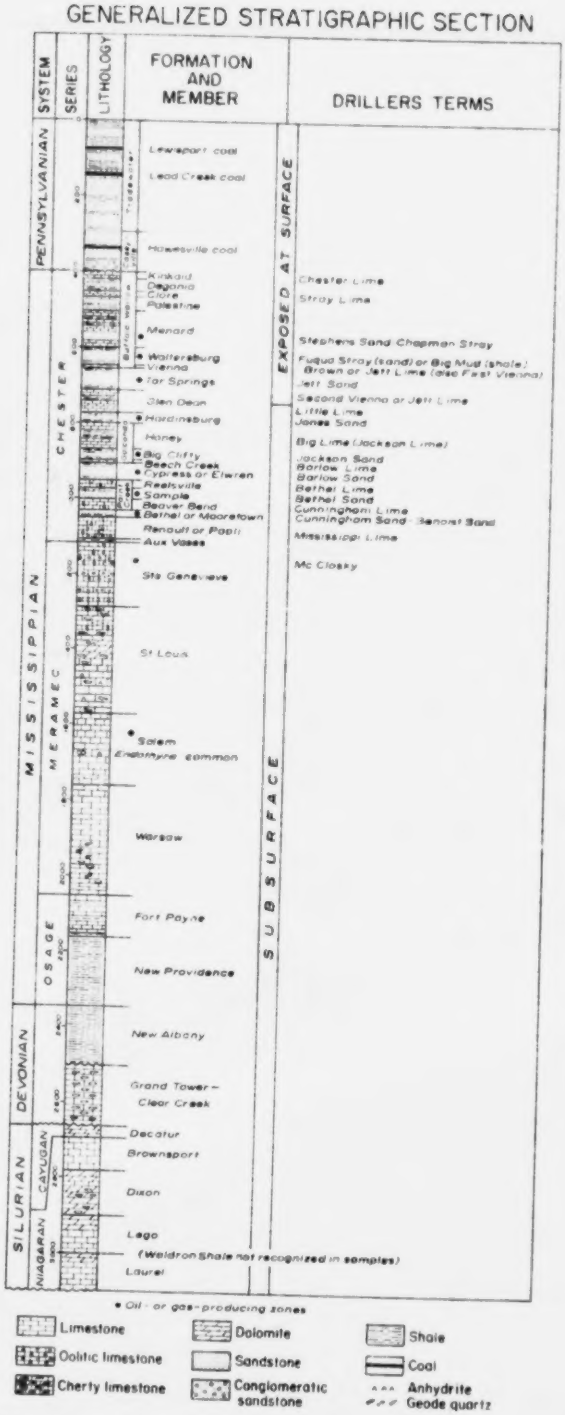
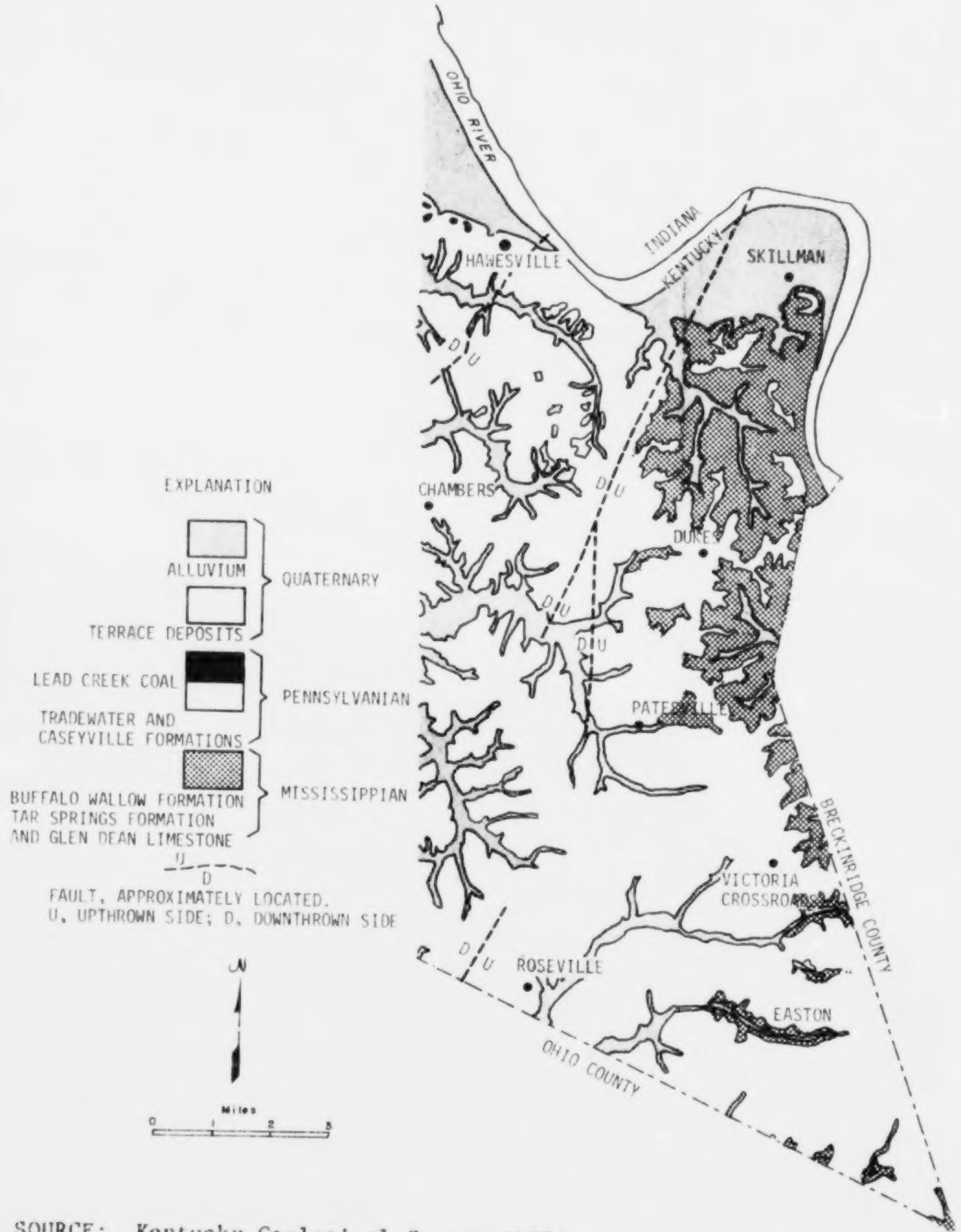

GENERALIZED STRATIGRAPHIC SECTION
SYSTEM
SERIES
LITHOLOGY
FORMATION AND MEMBER
DRILLERS TERMS
PENNSYLVANIAN
MISSISSIPPIAN
DEVONIAN
SILURIAN
CHESTER
MERAMEC
OSAGE
CAYUGAN
NIAGARAN
EXPOSED AT SURFACE
SUBSURFACE
Lewisport coal
Lead Creek coal
Tradewater
Hawesville coal
Caseyville
Kinkaid
Degonia
Clore
Palestine
Buffalo Wallow
Menard
Waltersburg
Vienna
Tar Springs
Glen Dean
Hardinsburg
Haney
Golconda
Big Clifty
Beech Creek
Cypress or Elwren
Reelsville
Sample
Paoli Creek
Beaver Bend
Bethel or Mooretown
Renault or Paoli
Aux Vases
Ste Genevieve
St Louis
Salem
Endothyra common
Warsaw
Fort Payne
New Providence
New Albany
Grand Tower – Clear Creek
Decatur
Brownsport
Dixon
Lego
(Waldron Shale not recognized in samples)
Laurel
Chester Lime
Stray Lime
Stephens Sand Chapman Stray
Fuqua Stray (sand) or Big Mud (shale)
Brown or Jett Lime (also First Vienna)
Jett Sand
Second Vienna or Jett Lime
Little Lime
Jones Sand
Big Lime (Jackson Lime)
Jackson Sand
Barlow Lime
Barlow Sand
Bethel Lime
Bethel Sand
Cunningham Lime
Cunningham Sand - Benoist Sand
Mississippi Lime
Mc Closky
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
• Oil - or gas-producing zones
Limestone
Oolitic limestone
Cherty limestone
Dolomite
Sandstone
Conglomeratic sandstone
Shale
Coal
Anhydrite
Geode quartz

SOURCE: Kentucky Geological Survey (1970)

Figure 3.3-8. Generalized Stratigraphic Section, Hancock County


OHIO RIVER
INDIANA
KENTUCKY
HAWESVILLE
SKILLMAN
CHAMBERS
DUKES
PATESVILLE
VICTORIA CROSSROADS
ROSEVILLE
EASTON
OHIO COUNTY
BRECKINRIDGE COUNTY
D U
EXPLANATION
ALLUVIUM
TERRACE DEPOSITS
QUATERNARY
LEAD CREEK COAL
TRADEWATER AND CASEYVILLE FORMATIONS
PENNSYLVANIAN
BUFFALO WALLOW FORMATION TAR SPRINGS FORMATION AND GLEN DEAN LIMESTONE
MISSISSIPPIAN
FAULT, APPROXIMATELY LOCATED. U, UPTHROWN SIDE; D, DOWNTHROWN SIDE
N
Miles
0
1
2
3

SOURCE: Kentucky Geological Survey (1970)

Figure 3.3-9. Geologic Map of Hancock County, Kentucky

QUATERNARY

Recent

Qay
Younger alluvium

Pleistocene

Qao
Older alluvium

Qlt
Lacustrine and terrace deposits

CARBONIFEROUS

MISSISSIPPIAN

Upper Mississippian

Mbw
Buffalo Wallow Formation

Mtg Mtss
Mgdl
*Tar Springs Formation and
Glen Dean Limestone
**Mtg, shale member of Tar Springs Formation
and upper member of Glen Dean Limestone
Mtss, sandstone member of Tar Springs Formation.
Shown by heavy line where too thin to show
pattern
Mgdl, lower member of Glen Dean Limestone

Mh
Hardinsburg Sandstone

Mgh
Haney Limestone Member

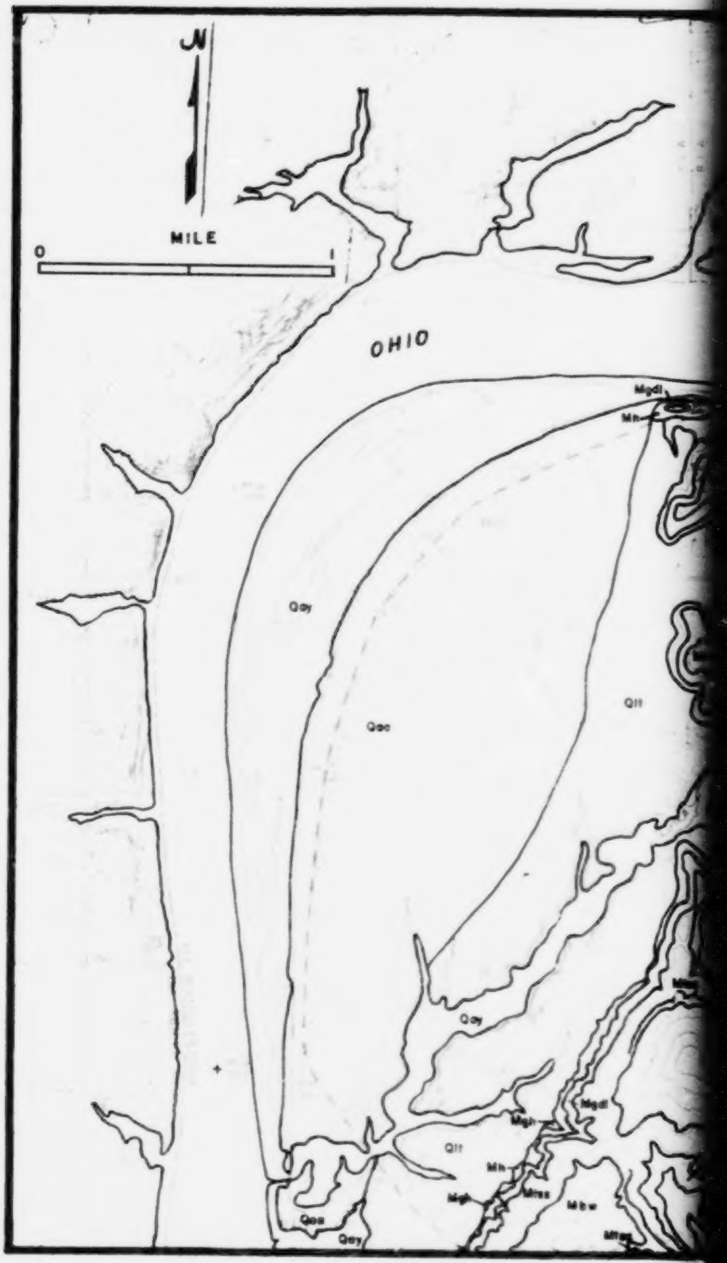
Mgb
Big Clifty Sandstone Member

Mgc
Beech Creek Limestone Member
Includes equivalent of Elwren Sandstone
of Malott (1919)

Mr
Reelsville Limestone

Msa
Sample Sandstone

Mbp
Beaver Bend and Paoli Limestones



SOURCE: Kentucky Geological Survey (1956b)

3-133-a

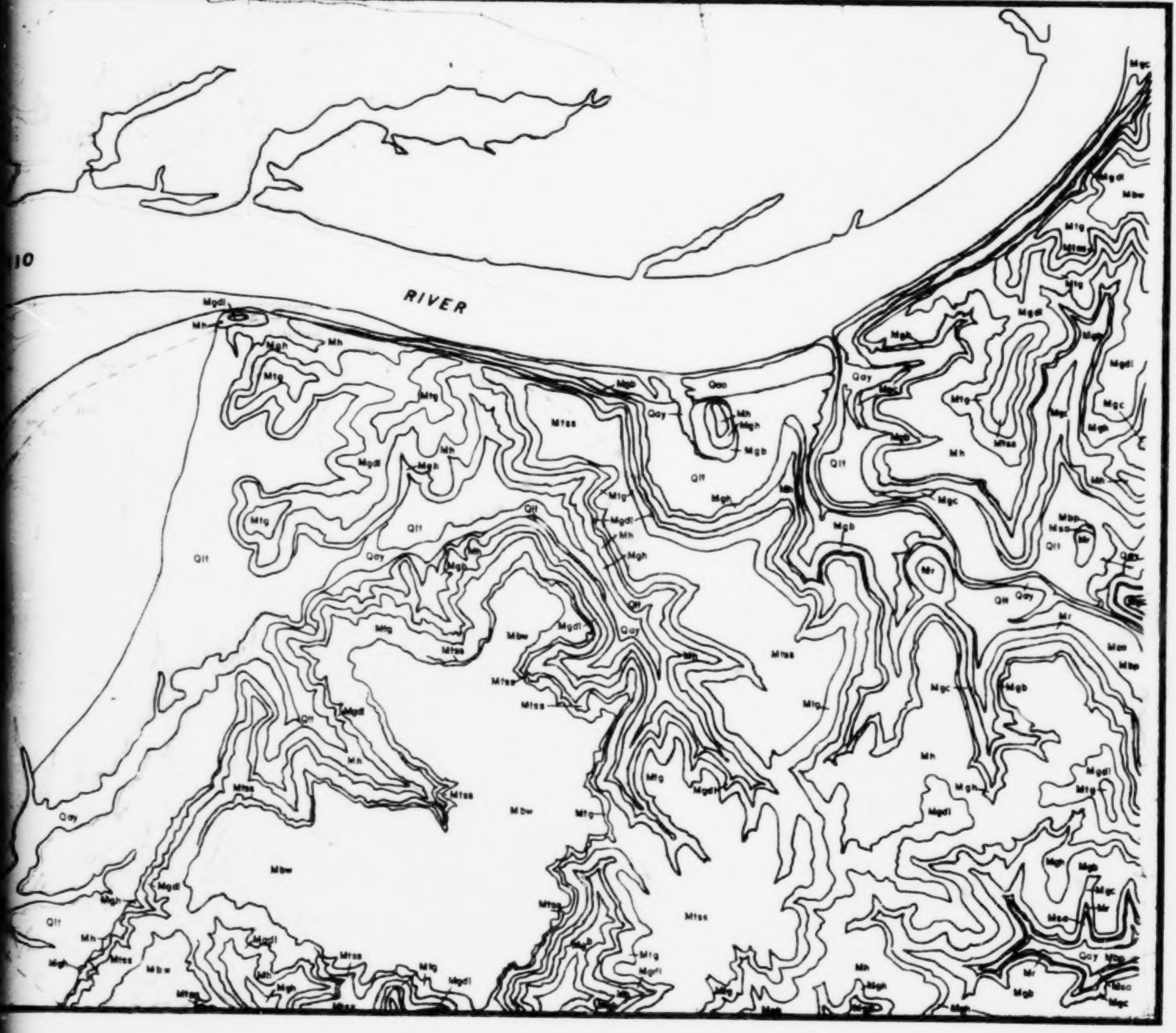

IIO
RIVER
Mgc
Mgdl
Mbw
Mtg
Mtss
Mh
Mgh
Mgb
Qao
Qay
Qlf
Mr
Msc
Mbp
Msa

Figure 3.3-10. Geology of the Breckinridge Site

Glen Dean Limestone, and Hardinsburg Sandstone Formation. The southeastern portion of the site ranges in elevation from 450 to 700 feet msl and is underlain by the Tar Springs Formation, Glen Dean Limestone, Hardinsburg Sand-Stone, and Buffalo Wallow Formation. Elevations of the Buffalo Wallow Formation rise to over 800 feet msl just to the south of the site boundary (Kentucky Geologic Survey 1965b).

3.3.2 Soils

The soils of west central Kentucky vary with the topography, which ranges from broad terraces and bottomlands along the Ohio River to steep upland ridges (Ohio River Basin Commission 1978). Soils along the Ohio River developed from alluvial and outwash deposits. Upland soils are discontinuous loess over weathered sandstone, shale, and limestone of varying depths and physical composition. Suitability of soil for various uses is related to slope, fertility, and drainage of the land.

3.3.2.1 Soils of the Project Area

Much of the terrain of Hancock and Breckinridge counties is rolling hills and upland with deep and moderately deep soils formed in residuum from acid shales, siltstone, and sandstone (USDA Soil Conservation Service 1975). The most extensive soil association on the uplands in Hancock and western Breckinridge counties is the Zanesville-Frondorf association (Figure 3.3-11). In eastern Breckinridge and western Hardin counties the Caneyville-Zanesville-Frondorf association is more common.

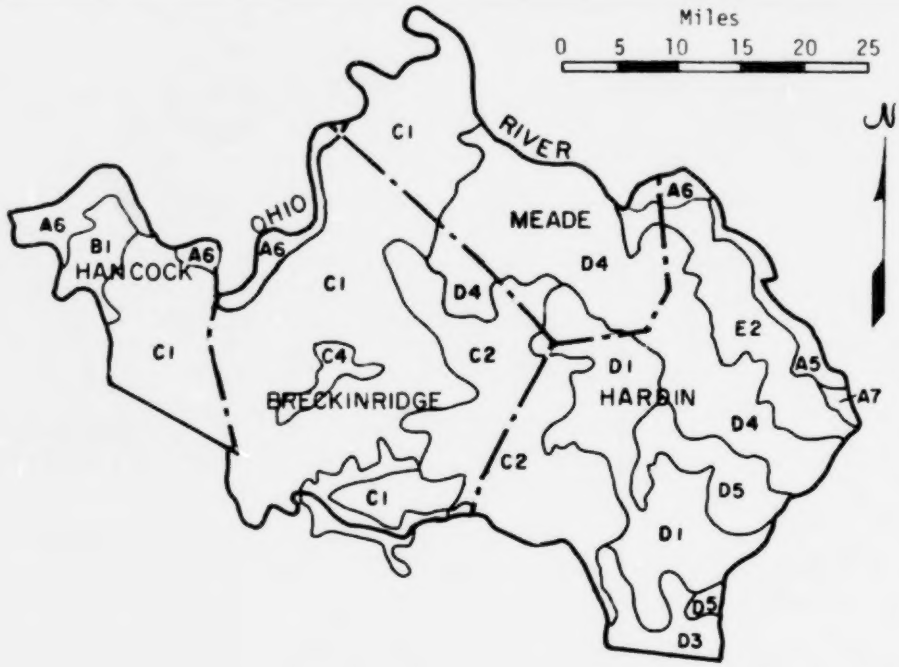
Along the nearly level floodplains and lower terraces of the Ohio River the soils range from deep, well drained to poorly drained. The most common association on these alluvial areas in Hancock and Breckinridge counties is the Elk-Weinback-Melvin assocation.

In central Hardin County, the soils are similar to those of the uplands in Hancock and Breckinridge counties except they are formed in residuum from limestone. The Crider-Cumberland association is most common in the vicinity of Elizabethtown.

3.3.2.2 Hancock Site

Hancock site soils are primarily composed of six major soil series: Wellston and Frondorf on the uplands, Loring and Grenada on gentle slopes, and Belknap and Elk along stream terraces (USDA Soil Conservation Service 1974).

> Wellston Series. The Wellston series consists of deep, well-drained soils that are sloping to moderately steep. They have formed in loess and in the underlying material weathered from sandstone, siltstone, and shale.
>
> In a representative profile, the surface layer is brown heavy silt loam about 5 inches thick. The subsoil is brown, friable light silty clay loam to a depth of about 26 inches. Below that depth, and extending to a depth of about 40 inches, it is yellowish-brown, mottled, firm heavy silt loam. The substratum is dark yellowish-brown mottled, firm fine sand loam. It is underlain by soft sandstone at a depth of about 60 inches.



A Deep, well-drained to poorly drained soils on nearly level flood plains and undulating terraces of the major streams (Fluvaquents-Hapludalfs).

A1 SHARKEY-COMMERCE association
A2 HUNTINGTON-MELVIN association
A3 FALAYA-HENRY association
A4 UNIONTOWN-PATTON association
A5 BELKNAP-KARNAK association
A6 ELK-WEINBACK-MELVIN association
A7 WHEELING-HUNTINGTON association
A8 POPE-BONNIE-ALLEGHENY association
A9 MOREHEAD-WHITLEY-CUBA association

B Deep, well drained to poorly drained soils, formed in loess on undulating and hilly uplands (Fragiudalfs)

B1 MEMPHIS-LORING association
B2 GRENADA-LORING association
B3 BRANDON-LORING-SAFFELL association

C Deep and moderately deep, well-drained soils, formed in residuum from acid shales, siltstone and sandstone with most areas having a thin loess mantle on hilly uplands and undulating broad ridgetops (Fragiudalfs-Hapludalfs)

C1 ZANESVILLE-FRONDORF association
C2 CANEYVILLE-ZANESVILLE-FRONDORF association
C3 LORING-WELLSTON association
C4 SADLER-ZANESVILLE association
C5 RINEY association

D Deep, well-drained soils, formed in residuum from limestone with most areas having a thin loess mantle on undulating to rolling upland plains (Paleudalfs)

D1 CRIDER-CUMBERLAND association
D2 BAXTER-CRIDER association
D3 FREDONIA-CUMBERLAND association
D4 CRIDER-VERTRESS association
D5 SONORA-GATTON association

E Deep and moderately deep, well-drained soils formed in residuum of cherty or shaly limestone on hilly uplands (Paleudults-Eutrochrepts)

E1 TRIMBLE-BAXTER association
E2 GARMON-FREDERICK association
E3 FREDERICK-MOUNTVIEW association

SOURCE: USDA Soil Conservation Service (1975)

Figure 3.3-11. Regional Soil Association

The root zone is deep. Available moisture capacity is high, and permeability is moderate.

Frondorf Series. The Frondorf series consists of moderately deep, well-drained soils that are strongly sloping to steep. They have formed in a thin deposit of loess and in material weathered from sandstone and siltstone.

In a representative profile, the surface layer is yellowish-brown silt loam about 7 inches thick. The subsoil is brown, friable silty clay loam to a depth of about 18 inches. Below that depth and extending to a depth of about 24 inches, it is yellowish-brown, mottled, friable gravelly silty clay loam. The substratum is mottled brown and light brownish-gray gravelly silty clay loam. It is underlain by soft sandstone bedrock at a depth of about 30 inches.

Available moisture capacity and permeability are moderate, and the root zone is moderately deep. In areas that have not been limed, the surface layer is very strongly acid.

Loring Series. In the Loring series are deep, moderately well drained, nearly level to moderately steep soils that have a fragipan. They have formed in loess.

In a representative profile, the surface layer is dark yellowish-brown silt loam about 7 inches thick. The upper part of the subsoil is bown, friable silty clay loam about 23 inches thick. The lower part of the subsoil is a fragipan of brown, mottled, very firm, brittle and compact silt loam about 24 inches thick. The underlying material is mottled dark yeallowish-brown, yellowish-brown, and pale-brown, friable silt loam that extends to a depth of 60 inches or more.

Available moisture capacity is moderate. Permeability is moderate above the fragipan and is slow in the fragipan. Roots and water readily penetrate the soil material above the fragipan, but their further penetration is restricted by the pan.

Grenada Series. The Grenada series consists of moderately well drained, nearly level or gently sloping, deep soils that have a fragipan. They have formed in loess.

In a representative profile, the surface layer is brown silt loam about 7 inches thick. The upper part of the subsoil is yellowish-brown, friable heavy silt loam that extends to a depth of about 16 inches. The next layer is mottled pale-brown and dark yellowish-brown, firm silt loam that extends to a depth of about 22 inches. The lower part of the subsoil is a very firm, very compact and brittle fragipan of mottled yellowish-brown and dark yellowish-brown silt loam. the fragipan is underlain by a layer of mottled yellowish-brown and brown, firm silty clay loam that extends from a depth of about 36 inches to a depth of 50 inches or more.

Available moisture capacity is moderate, the content of organic matter is low, and natural fertility is moderately low. Permeability is moderate above the fragipan and is slow in the fragipan. Roots and water easily penetrate the soil material above the fragipan, but penetration is restricted in the fragipan.

Belknap Series. The Belknap series consists of deep, nearly level soils that are acid and are somewhat poorly drained. They have formed in alluvium washed from loess.

In a representative profile, the surface layer is brown silt loam about 6 inches thick. The subsoil is brown, mottled, friable silt loam to a depth of about 18 inches. Below that depth and extending to a depth of about 30 inches, it is grayish-brown, mottled, friable silt loam. The substratum, also mottled, is grayish-brown, very friable silt loam in the upper part and is dark-gray, very friable silt loam in the lower part. The substratum extends to a depth of 50 inches or more.

Available moisture capacity is high, and permeability is moderate. Natural fertility is moderate, and the content of organic matter is low. Penetration of roots and moisture is good if artificial drainage is provided to lower the seasonal high water table.

Elk Series. The Elk series consists of deep, well-drained soils that are nearly level to steep. They have formed in mixed alluvium deposited by the Ohio and the Green Rivers.

In a representative profile, the surface layer is dark-brown silt loam about 8 inches thick. The subsoil is brown light silty clay loam that is friable in the upper part and is firm in the lower part.

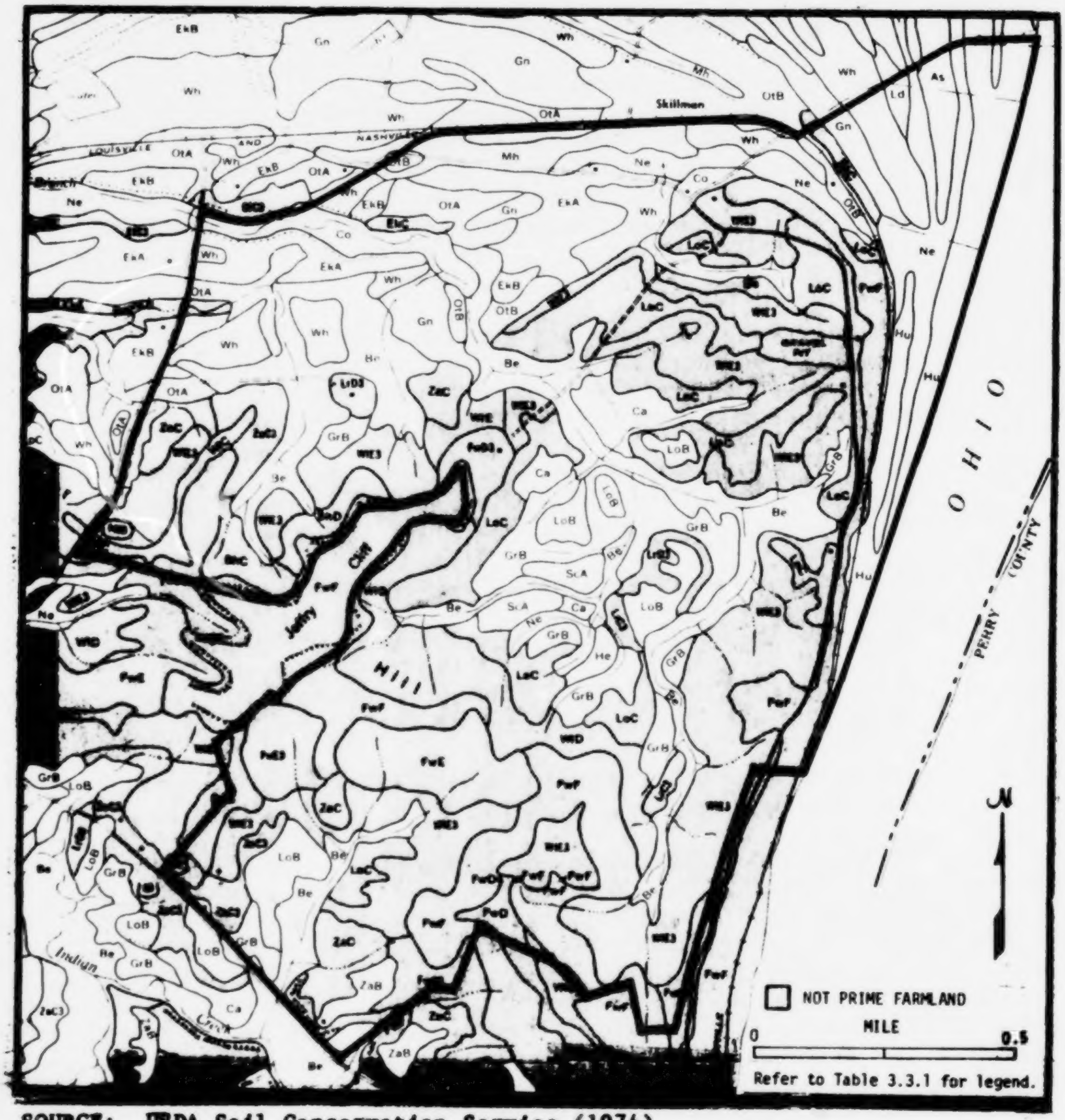
It is underlain at a depth of about 36 inches by dark yellowish-brown, friable loam that extends to a depth of 50 inches or more.

Available moisture capacity is high. Permeability is moderate, and the root zone is deep.

Soils of the Hancock site, as surveyed and mapped by SCS (1974), are shown in Figure 3.3-12. The legend for the soil types on the map is in Table 3.3-2. This table also contains the texture, slope, depth from surface, depth to bedrock, depth to seasonal high water table, and reaction for each soil type. Many of the soil types at Hancock site have been designated as prime farmland soils by the Kentucky State Conservationist (1979). To qualify as prime farmland, some of these soils must be subject to less frequent flooding than once in 2 years during the growing season and/or must have adequate drainage to a sufficient depth during the cropping season to allow cultivated crops common to the area to be grown. Onsite investigation may be needed to determine whether the soils are classifiable as prime farmland. Soils of the ridges in the southern portion of the site, those associated with Jeffry Cliff, and certain soils in the northeastern portion of the site are not prime farmland.

3.3.2.3 Breckinridge Site

A soil survey has not been published for Breckinridge County, although preliminary soil mapping has been conducted in the vicinity of the


OHIO
PERRY COUNTY
Jeffry Cliff
Hill
Skillman
Louisville and Nashville
Indian Creek
N
NOT PRIME FARMLAND
MILE
0
0.5
Refer to Table 3.3.1 for legend.

SOURCE: USDA Soil Conservation Service (1974)
USDA Soil Conservation Service, State Conservationist for the Commonwealth of Kentucky (1979)

Figure 3.3-12. Soil Associations, Hancock Site

Table 3.3-2. Soil Types, Hancock Site

Map Unit	Slope	Soil Series	Depth to Bedrock (feet)	Depth to Seasonal High Water Table (feet)	Texture	Depth from Surface (inches)	Reaction pH
As[1,2]	0-4%	Ashton	>50	>3	Silt loam	0-7	7.3-7.8
					Silty clay loam	7-54	5.5-7.3
					Heavy silty clay loam	54-60	5.5-6.5
Be[1,3,4]	0-2%	Belknap	>7	0.5-1.5	Silt loam	0-50	4.5-5.5
Ca[4]	0-4%	Calloway	>4	0.5-1.5	Silt loam	0-27	5.5-6.0
					Heavy silt loam (fragipan)	27-50	5.0-6.5
Co[1,3]	0-2%	Collins	>10	1.5-3.0	Silt loam	0-60	4.5-5.5
EkA[2]	0-2%	Elk	>50	>6	Silt loam	0-8	5.6-6.0
EkB[2]	2-6%				Light silty clay loam	8-36	4.5-5.0
EkC	6-12%				Loam	36-50	5 1-5.5
EkE	12-50%						
ElC3	6-12%, severely eroded						
FWD	12-20%	Frondorf	1.5-3.5	>6	Silt loam	0-7	4.5-6.0
FWD3	12-20%, severely eroded				Silty clay loam	7-18	4.5-6.0
FWE	20-30%				Gravelly silty clay loam	18-30	4.5-6.0
FHE3	20-30%, severely eroded				Bedrock	30	–
FWF	30-50%						
For Wellston part, see Wellston series							
Gn[4]	0-2%	Ginat	>50	0-0.5	Silt loam	0-20	4.5-6.0
					Heavy silt loam (fragipan)	20-26	4.5-6.0
					Silty clay loam (fragipan)	26-40	4.5-6.0
					Silty clay loam	40-52	4.5-6.0
GrA[2]	0-2%	Granada	>6	1.5-2.5	Silt loam	0-7	5.6-6.0
GrB[2]	2-6%				Heavy silt loam	7-22	5.1-6.0
					Silt loam (fragipan)	22-36	5.1-6.0
					Silty clay loam	36-50	5.1-6.5
He[4]	0-4%	Henshaw	>20	1-2	Silt loam	0-9	6.1-6.5
					Silty clay loam	9-45	5.0-6.5
					Silt loam	45-60	6.1-7.8
Hu[1,3]	0-4%	Huntington	>50	>3	Silt loam	0-60	6.1-7.8
Ld[1,3]	0-2%	Lindside	>20	1.5-3.0	Silt loam	0-50	5.6-6.5
LoA	0-2%	Loring	6-12	2-6	Silt loam	0-7	5.6-6.0
LoB	2-6%				Light silty clay loam	7-30	5.1-6.0
LoC	6-12%				Silt loam (fragipan)	3-54	5.1-5.5
LoD	12-25%				Silt loam	54-60	5.1-6.5
LrC3	6-12%, severely eroded						
LrD3	12-25%, severely eroded						
Mh[1,3,4]	0-2%	Melvin	>50	0-0.5	Silt loam	0-50	6.1-6.5
Ne[1,3,4]	0-2%	Newark	>20	0.5-1.5	Silt loam	0-9	5.6-6.0
					Silt loam	9-32	5.6-7.3
					Silt loam	32-60	5.6-7.8
OtA[2]	0-2%	Otwell	>50	1.5-2.5	Silt loam	0-7	5.6-6.0
OtB[2]	2-6%				Silt loam	7-26	4.5-5.0
					Heavy silt loam (fragipan)	26-40	4.5-5.0
					Heavy silt loam	40-60	5.1-5.5
ScA[2]	0-2%	Sciotoville	>50	1.5-2.5	Loam	0-7	6.1-6.5
					Loam	7-27	4.5-5.0
					Loam (fragipan)	27-52	4.5-5.0
					Loam	52-60	4.5-5.0
Wh[3,4]	0-2%	Weinbach	>50	0.5-1.5	Silt loam	0-8	5.6-6.0
					Heavy silt loam	8-24	4.5-5.5
					Silt loam (fragipan)	24-40	4.5-5.0
					Silty clay loam	40-50	5.1-5.5
WlC	6-12%	Wellston	3-6	>6	Heavy silt loam	0-5	5.6-6.0
WlC3	6-12%, severely eroded				Light silty clay loam	5-26	5.1-5.5
WlD	12-20%				Heavy silt loam	26-40	4.5-5.0
WlE	20-30%				Fine sandy loam	40-60	4.5-5.0
WlE3	12-30%, severely eroded				Bedrock	60	–
ZaB[2]	2-6%	Zanesville	4-6	2-2.5	Silt loam	0-8	4.5-5.5
ZaC	6-12%				Heavy silt loam	8-26	4.5-5.5
ZaC3	6-12%, severely eroded				Silt loam (fragipan)	26-60	4.5-5.5
					Bedrock	60	–

---

[1] Subject to flooding.

[2] Prime farmland.

[3] Prime farmland if subject to less frequent flooding than once in 2 years during the growing season.

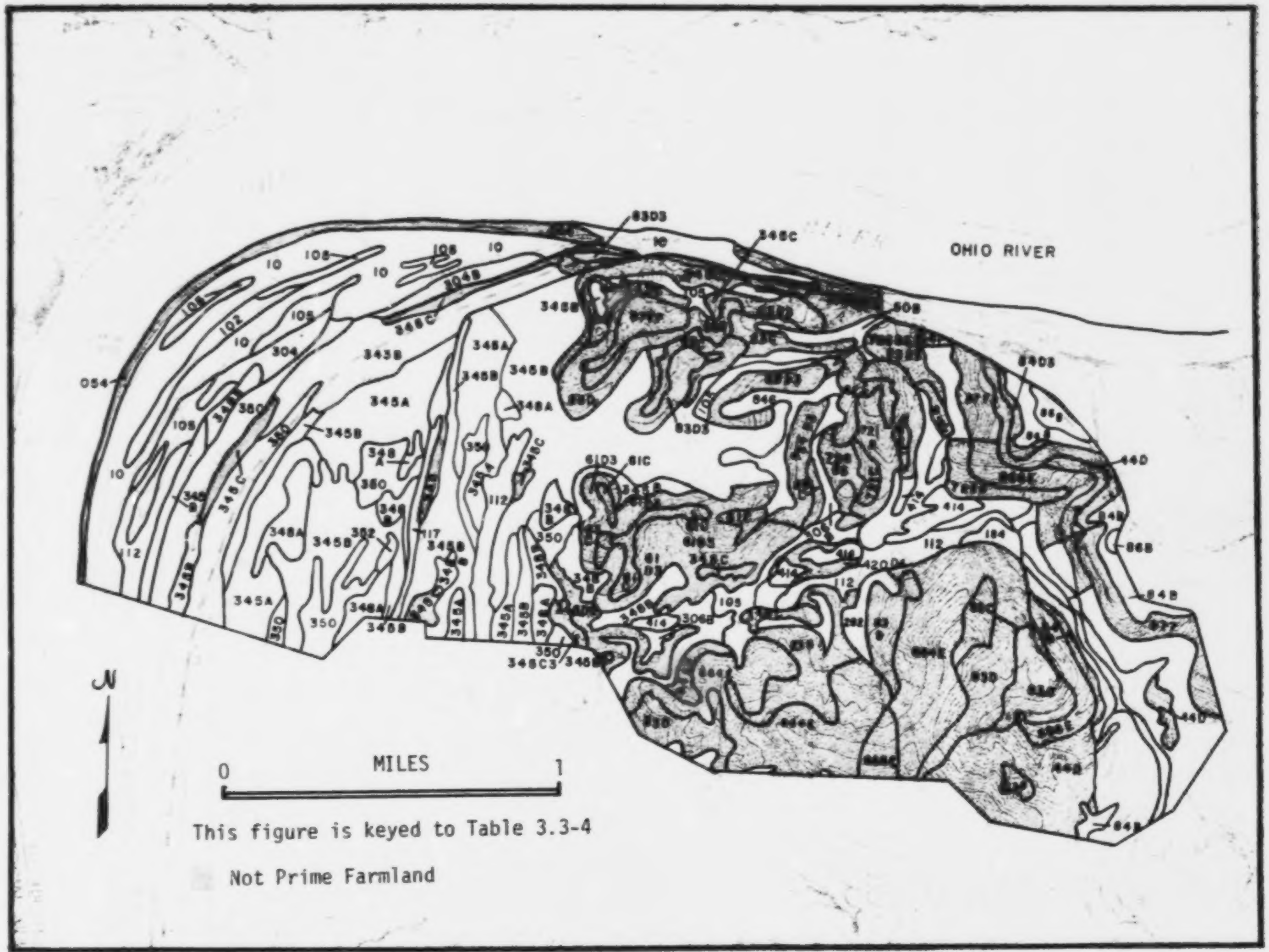
[4] Prime farmland if adequate drainage to a sufficient depth during the cropping season to allow growth of cultivated crops

Sources: USDA Soil Conservation Service (1974); Soil Survey of Daviess and Hancock Counties, Kentucky; SCS State Conservationist for the Commonwealth of Kentucky (1979); Prime Farmland Soils of Kentucky. Kentucky Inventory and Monitoring Bulletin No. KY42-9-4.

Breckinridge site (Breckinridge County SCS, personal communication 1980). Figure 3.3-13 shows the preliminary soil map of the site, and Table 3.3-3 contains a listing of the soil types at the site along with their texture and slope.

Four common soil types identified to date (1980) on the Breckinridge site are Wellston on the uplands, Weinbach and Wheeling on the terraces and gentle slopes, and Huntington on the floodplain. The Wellston series is as described in Subsection 3.3.2.2. Descriptions of the three other major soil series are (USDA Soil Conservation Service 1974):

> Weinbach Series. The Weinbach series consists of somewhat poorly drained, deep, nearly level soils that have a fragipan. These soils have formed in alluvium from several different sources.
>
> In a representative profile, the surface layer is dark grayish-brown silt loam about 8 inches thick. The subsoil is about 32 inches thick. It is mottled yellowish-brown, grayish-brown, and light brownish-gray, friable hevy silt loam to a depth of about 24 inches. Below that depth, the subsoil is a firm and brittle fragipan of mottled light-gray and yellowish-brown silt loam. The substratum is mottled light-gray and yellowish-brown silty clay loam that extends to a depth of 50 inches or more.
>
> Available moisture capacity is moderate, natural fertility is moderately low, and the content of organic matter is low. Permeability is moderate above the fragipan, but it is slow in the pan.
>
> Wheeling Series. The Wheeling series consists of deep, well-drained soils that are nearly level to sloping. These soils have formed in alluvium deposited by the Ohio River.
>
> In a representative profile, the surface layer is brown loam about 7 inches thick. The subsoil is brown, friable light clay loam in the upper part and is brown, friable heavy loam in the lower part. It is underlain at a depth of about 25 inches by yellowish-brown, mottled, friable fine sandy loam that extends to a depth of 50 inches or more.
>
> Available moisture capacity is high, natural fertility is moderate, and the content of organic matter is low. Natural fertility and permeability are moderate. The root zone is deep.
>
> Huntington Series. The Huntington series consists of nearly level soils that are deep and well drained. They have formed in mixed alluvium derived from loess, glacial till, limestone, sandstone, siltstone, and shale.
>
> In a representative profile, the surface layer is dark-brown silt loam about 8 inches thick. The subsoil is dark-brown, friable silt loam to a depth of about 18 inches. Below that depth and extending to a depth of 60 inches or more, it is brown, friable silt loam.
>
> Available moisture capacity is high, and permeability is moderate. The content of organic matter is medium. Natural fertility is very high. The root zone is deep.


OHIO RIVER
N
MILES
0
1
This figure is keyed to Table 3.3-4
Not Prime Farmland
8303
10
345C
509
108
3048
345B
345A
348A
348C
350
112
054
105
102
304
380
6103
61C
414
184
120D
44D
86B
84B
87
117
3068
348C3

SOURCE: USDA Soil Conservation Service, Personal communication (1980)
USDA Soil Conservation Service, State Conservationist
for the Commonwealth of Kentucky (1979)

Figure 3.3-13. Soil Associations, Breckinridge Site

Table 3.3-3. Preliminary Soil Types, Breckinridge Site

Map Unit	Soil Series	Texture	Slope
304[1,2]	Ashton	Silt loam	0 to 2%
304B[2]	Ashton	Silt loam	2 to 6%
054	Breaks and alluvial land	–	–
724D	Caneyville	Very rocky silt loam	12 to 20%
726D3	Caneyville	Silty clay	12 to 20%, severely eroded
306B[2]	Captina	Silt loam	2 to 6%
721C	Christian	Silt loam	6 to 12%
61C	Crider	Silt loam	6 to 12%
61D3	Crider	Silt loam	12 to 20%, severely eroded
102[1,3]	Egam	Silt loam	Nearly level
864E	Gilpin	Silty clay loam	20 to 30%
352[4]	Ginat	Silt loam	Level
10[1,3]	Huntington	Silt loam	Level
105[1,3]	Lindside	Silt loam	Level
414[3,4]	McGary	Silt loam	0 to 2%
420C3	Markland	Silt loam	6 to 12%, severely eroded
420D9	Markland	Silt loam	12 to 20%
117[1,3,4]	Melvin	Silt loam	Level
50B[2]	Memphis	Silt loam	2 to 6%
112[1,3,4]	Newark	Silt loam	Level
60C	Pembroke	Silt loam	6 to 12%
62C	Russelville	Silt loam	6 to 12%
86B[2]	Sadler	Silt loam	2 to 6%
348A[2]	Sciotoville	Silt loam	0 to 2%
348B[2]	Sciotoville	Silt loam	2 to 6%
44D	Shelocta	Gravelly silt loam	12 to 20%
184[3,4]	Stendal	Silt loam	Level
886	Weikert-Gilpin	Stony soils	15 to 50%
877	Weikert	Stony soils	15 to 50%
886E	Weikert-Gilpin	Stony soils	20 to 30%
350[3,4]	Weinbach	Silt loam	Nearly level
83C	Wellston	Silt loam	6 to 12%
83D	Wellston	Silt loam	12 to 20%
83D3	Wellston	Silt loam	12 to 20%, severely eroded
343A[2]	Wheeling	Fine sandy loam	0 to 2%
343B[2]	Wheeling	Fine sandy loam	2 to 6%
345A[2]	Wheeling	Silt loam	0 to 2%
345B[2]	Wheeling	Silt loam	2 to 6%
345C3	Wheeling	Silty clay loam	6 to 12%, severely eroded
345D	Wheeling	Silt loam	–
84B[2]	Zanesville	Silt loam	2 to 6%
84C3	Zanesville	Silt loam	6 to 12%, severely eroded

---

[1] Subject to flooding.

[2] Prime farmland.

[3] Prime farmland if subject to less frequent flooding than once in 2 years during the growing season.

[4] Prime farmland if adequate drainage to a sufficient depth during the cropping season to allow growth of cultivated crops common to the area.

Sources: USDA Soil Conservation Service. Breckinridge County Kentucky Preliminary Soil Survey Data. Breckinridge County SCS, personal communication, 1980.

SCS State Conservationist for the Commonwealth of Kentucky (1979). Prime Farmland Soils of Kentucky. Kentucky Inventory and Monitoring Bulletin No. KY 42-9-4.

Many of the soil types identified to date at the Breckinridge site have been designated as prime farmland soils (Kentucky State Conservationist 1979). Again, primarily because of flooding characteristics, an onsite investigation probably would be necessary for a determination of prime farmland status. Breaks and alluvial land along the western and northwestern edge of the site and soils occupying steep slopes in the eastern portion of the site are not prime farmland.

3.3.3 Vegetation

The vegetational region of the project area is the Western Mesophytic Forest of the Deciduous Forest Formation in eastern North America (Braun 1950). The Western Mesophytic Forest is a transition region where mixed mesophytic forests that dominate eastern Kentucky become limited in extent, and oak forests become frequent and dominant. Thus, forest communities of the area form a mosaic that reflects underlying rock formations and topography, as well as present and historical land use.

3.3.3.1 Vegetation Cover Types of the Project Area

Although the vast forests that originally covered this portion of Kentucky have been reduced and altered by agricultural development, forest communities are still extensive in the project area. Upland hardwoods form the most common forest cover type, with large areas of second-growth upland hardwoods in the Hoosier National Forest and on the potential transmission corridor south of the Hancock site (see Figure 3.1-4). Lowland hardwoods are interspersed throughout the project area, primarily along streams. On the Breckinridge and Hancock sites, cropland and pasture constitute the most extensive land cover. This type of agrigultural cover also dominates most of the Elizabethtown corridor. Minor cover types within the project area include old fields, coniferous forests, tree farms, and wetlands.

A 1979-1980 survey of the project area cover types revealed approximately 200 plant species (Table 3.3-4). None of the plants observed is Federally endangered or threatened; nor was any species on the Kentucky nature Preserves Commission Plant Element List observed. Further, no records exist of these species on either site, either potential transmission corridor, or the Elizabethtown corridor. Those plant species typically associated with each cover type are included in the following cover type characterizations.

3.3.3.1.1 Cropland and Pasture

Cropland and pasture comprise two vegetation types: cultivated fields and fallow fields. Cultivated fields dominate the Ohio River floodplain, lower terraces of the river, other broad valleys, and level terrain in upland areas. Fallow fields, which are often used for hay and pasture, are more limited and generally occur where terrain and/or soils limit cultivation.

3.3.3.1.1.1 Cultivated Fields

Typical of the geographic region, major crops in the project area are soybeans, corn, and tobacco. Soybean cultivation is common on alluvial flats and lower terraces of the Ohio River, while corn and tobacco are more common on gently rolling hills and plateaus.

Table 3.3-4. Checklist of Plant Species Observed in the Project Area, 1979-1980 (Sheet 1 of 3)

Scientific Name	Common Name	Scientific Name	Common Name
Acer negundo	Boxelder	*Carya cordiformis*	Bitternut hickory
Acer rubrum	Red maple	*Carya glabra*	Pignut hickory
Acer saccharinum	Silver maple	*Carya ovata*	Shagbark hickory
Acer saccharum	Sugar maple	*Carya tomentosa*	Mockernut Hickory
Achillea millefolium	Milfoil (yarrow)	*Carya* sp.	Hickory
Actaea alba	White baneberry	*Celtis occidentalis*	Hackberry
Actinomeris alternifolia	Wingstem	*Cephalanthus occidentalis*	Buttonbush
Aesculus glabra	Ohio buckeye	*Cerastium vulgatum*	Mouse-ear chickweed
Agrimonia mollis	Agrimony	*Cercis canadensis*	Redbud
Agrimonia parviflora	Swamp agrimony	*Chichorium intybus*	Chickory
Allium canadense	Wild onion	*Chimaphila maculata*	Spotted wintergreen
Ambrosia artemisifolia	Ragweed	*Cinna arundinacea*	Wood reed
Andropogon virginicus	Broom sedge	*Cirsium vulgare*	Bull thistle
Anemonella thalictroides	Windflower	*Claytonia virginica*	Spring beauty
Antennaria solitaria	Pussy-toes	*Convolvulus arvensis*	Field bindweed
Aralia spinosa	Hercules club	*Cornus florida*	Flowering dogwood
Arisaema dracontium	Green dragon	*Cryptotaenia canadensis*	Honewort
Arisaema triphyllum	Jack in the pulpit	*Cyperus esculentus*	Nut grass
Aristida sp.	Three awn grass	*Cystopteris bulbifera*	Bulblet bladder fern
Asarum canadense	Wild ginger	*Cystopteris fragilis*	Bladder fern
Asimina triloba	Pawpaw	*Daucus carota*	Queen Anne's lace
Asplenium platyneuron	Ebony spleenwort	*Delphinium tricorne*	Dwarf larkspur
Aster lateriflorus	Calico aster	*Dentaria heterophylla*	Slender toothwort
Aster sp.	Aster	*Dentaria laciniata*	Cut-leaved toothwort
Asteraceae		*Desmodium paniculatum*	Panicled tick trefoil
Bidens bipinnata	Spanish needles	*Desmodium perplexum*	Beggar lice
Boehmeria cylindrica	False nettle	*Dicentra canadensis*	Squirrel corn
Botrychium obliquum	Common grapefern	*Dicentra cucullaria*	Dutchman's breeches
Botrychium virginianum	Rattlesnake fern	Dicotyledonae	
Brachyelytrum erectum	Bearded shorthusk	*Digitaria filiformis*	Crab grass
Campsis radicans	Trumpet vine	*Diodia teres*	Buttonweed
Carex pensylvanica	Pennsylvania sedge	*Dioscorea quarternata*	Wild yam
Carex sp.	Sedge	*Diospyros virginiana*	Persimmon
Carpinus caroliniana	American hornbeam	*Dryopteris marginalis*	Marginal shield-fern

Table 3.3-4. Checklist of Plant Species Observed in the Project Area, 1979-1980 (Sheet 2 of 3)

Scientific Name	Common Name	Scientific Name	Common Name
Dryopteris sp.	Woodfern	*Liquidambar styraciflua*	Sweetgum
Eleocharis sp.	Spike rush	*Liriodendron tulipifera*	Yellow poplar
Equisetum hyemale	Scouring rush	*Lonicera japonica*	Japanese honeysuckle
Erechtites hieracifolia	Fireweed	*Morus rubra*	Red mulberry
Erigeron philadelphicus	Marsh fleabane	*Nyssa sylvatica*	Black gum
Erigeron strigosus	Daisy fleabane	*Opuntia humifusa*	Prickly pear cactus
Erythronium americanum	White trout lily	*Osmorhiza claytonia*	Sweet cicely
Euonymus americanus	Strawberry bush	*Oxalis stricta*	Wood sorrel
Eupatorium coelestinum	Mistflower	*Oxalis violacea*	Violet wood sorrel
Eupatorium perfoliatum	Common boneset	*Oxydendron arboreum*	Sourwood
Eupatorium rugosum	White snakeroot	*Panicum* sp.	Panic grass
Eupatorium sp.	Thoroughwort	*Parthenocissus quinquefolia*	Virginia creeper
Euphorbia maculata	Nodding spurge	*Phacelia bipinnatifida*	Phacelia
Fabaceae		*Phaseolus polystachios*	Wild bean
Fagus grandifolia	Beech	*Phryma leptostachya*	Lopseed
Festuca sp.	Fescue	*Pilea pumila*	Clearweed
Fraxinus americana	White ash	*Pinus echinata*	Shortleaf pine
Galium aparine	Cleavers	*Pinus resinosa*	Red pine
Galium circaezans	Wild licorice	*Pinus strobus*	White pine
Galium sp.	Bedstraw	*Pinus taeda*	Loblolly pine
Geum canadense	Avens	*Pinus virginiana*	Virginia pine
Gnaphalium obtusifolium	Rabbit tobacco	*Plantago lanceolata*	English plantain
Hepatica acutiloba	Liverleaf	*Plantago rugelii*	Red-stalked plantain
Houstonia sp.	Bluets	*Plantago virginica*	Dwarf plantain
Hydrangea arborescens	Hydrangea	*Platanus occidentalis*	Sycamore
Hydrocotyle sp.	Water pennywort	Poaceae	
Impatiens biflora	Jewelweed	*Podophyllum peltatum*	Mayapple
Ipomaea pandurata	Morning glory	*Polygala sanguinea*	Milkwort
Juglans cinera	Butternut	*Polygonatum biflorum*	Solomon's seal
Juncus dichotomus	Forked-rush	*Polygonum densiflorum*	Smartweed
Juniperus virginiana	Eastern redcedar	*Polystichum acrostichoides*	Christmas fern
Lespedeza cuneata	Sericea lespedeza	*Prenanthes* sp.	Rattlesnake root
Lespedeza sp.	Lespedeza	*Prunella vulgaris*	Self-heal
Lindera benzoin	Spicebush	*Prunus serotina*	Black cherry

Table 3.3-4. Checklist of Plant Species Observed in the Project Area, 1979-1980 (Sheet 3 of 3)

Scientific Name	Common Name	Scientific Name	Common Name
Pycnanthemum tenuifolium	Narrow-leaved mountain mint	*Smilax glauca*	Greenbriar
Quercus alba	White oak	*Smilax hispida*	Greenbriar
Quercus coccinea	Scarlet oak	*Smilax* sp.	Greenbriar
Quercus falcata	Southern red oak	*Solanum carolinense*	Horsenettle
Quercus muehlenbergii	Chinkapin oak	*Solidago altissima*	Goldenrod
Quercus prinus	Chestnut oak	*Solidago juncea*	Goldenrod
Quercus rubra	Northern red oak	*Solidago rugosa*	Goldenrod
Quercus velutina	Black oak	*Solidago* sp.	Goldenrod
Ranunculus arbortivus	Small-flowered buttercup	*Sorghum halepense*	Johnson grass
Ranunculus recurvatus	Hooked buttercup	*Sparganium* sp.	Bur-reed
Ranunculus sp.	Buttercup	*Sullivantia sullivantii*	Sullivantia
Rhus copallina	Winged sumac	*Tilia americana*	Basswood
Rhus glabra	Smooth sumac	*Tradescantia subaspera*	Spiderwort
Rhus radicans	Poison ivy	*Trifolium pratense*	Red clover
Robinia pseudoacacia	Black locust	*Trifolium repens*	White clover
Rubiaceae		*Trifolium* sp.	Clover
Rubus allegheniensis	Blackberry	*Trillium sessile*	Trillium
Rudbeckia hirta	Black-eyed Susan	*Typha latifolia*	Cattail
Rumex acetosella	Sheepsorrel	*Ulmus alata*	Winged elm
Sabatia angularis	Rose-pink	*Ulmus americana*	American elm
Salix nigra	Black willow	*Ulmus rubra*	Slippery elm
Salix sp.	Willow	*Uniola latifolia*	Spike grass
Sambucus canadensis	Elderberry	*Veronia fasciculata*	Common ironweed
Sanguinaria canadensis	Bloodroot	*Verbena hastata*	Blue vervain
Sassafras albidum	Sassafras	*Verbena urticifolia*	White vervain
Schizachne purpurascens	False-melic grass	*Viburnum acerifolium*	Arrow-wood
Sedum ternatum	Stonecrop	*Vicia villosa*	Hairy vetch
Setaria sp.	Foxtail grass	*Vicia* sp.	Vetch
Silene virginica	Firepink	*Viola papilionacea*	Common blue violet
Smilacina racemosa	False Solomon's-seal	*Viola sororia*	Woolly blue violet
Smilacina sp.		*Vitis vulpina*	Frost grape
		Xanthium strumarium	Cocklebur

Source: Texas Instruments Incorporated field data (1979-1980).

References: Radford et al. (1968).
Wharton and Barbour (1971).
Courtenay and Zimmerman (1972).
Wharton and Barbour (1973).

3.3.3.1.1.2 Fallow Fields

Fallow fields, which may be idle cropland or pasture, are common on gently- to strongly-sloping silt loam soils in locations where drainage is poor or erosion hazard is high. The vegetation is primarily grasses and forbs. Typical grass and sedge species include broom sedge, fescue, crab grass, nut grass, foxtail grass, bearded shorthusk, and wood reed. The more common forbs are lespedeza, clover, ragweed, ironweed, goldenrod, horse nettle, calico aster, boneset, white snakeroot, and mistflower. Low-lying wet locations contain a greater number of rushes and sedges. Some of these locations are flooded most of the year.

Vegetation cover and density in the fallow fields typically increase through the summer and early fall. Locations in later stages of abandonment exhibit the highest plant density of any of the cover types in the study area. This high density generally is attributable to the progressive development toward dominance by grass species.

3.3.3.1.2 Old Fields

Old fields of various successional stages are located throughout the project area. Vegetation composition reflects time since abandonment, soil and rock substrate, and treatment prior to abandonment. The usual course of old field succession in the region is from annual forbs and grasses as predominant species to perennials to woody shrubs and finally to forest species. Typically, old field communities composed of broom sedge, goldenrod, and smilax are invaded by winged sumac, sassafras, persimmon, eastern redcedar, dogwood, and oaks, especially white oak (Braun 1950).

Old fields in the project area are distinguished from fallow fields by a greater number of perennial herbaceous species and the presence of early successional woody shrub and tree species.

3.3.3.1.3 Upland Hardwoods Forest

The upland hardwoods cover type, which occupies plateaus, ridges, and gently rolling hills not used for farmland, is primarily composed of oak-hickory forests, although there are limited areas of mixed mesophytic associations. The oak-hickory forests generally occupy drier, more shallow soils on moderately sloping to steep hillsides and ridges. Most of the upland hardwoods soils are well drained silt loams that are highly susceptible to erosion due to topography (SCS 1974).

Typical species in the oak-hickory forests of the project area are white oak, northern red oak, chinkapin oak, chestnut oak, black oak, shagbark hickory, pignut hickory, mockernut hickory, sugar maple, yellow poplar, and white ash. Predominate understory species include oak and hickory saplings, sugar maple, dogwood, slippery elm, sourwood, white ash, and sassafras.

Ground cover vegetation in the oak-hickory forests includes vines, forbs, and tree seedlings. Japanese honeysuckle, poison ivy, and Virginia creeper are common vines throughout the project area. Forbs vary somewhat with the season, but commonly occurring species include woolly blue violet, slender toothwort, cleavers, and Solomon's seal. Typical tree seedlings in the ground cover stratum include sugar maple, dogwood, white oak, and black cherry. The greatest variety of herbaceous species is present in the spring when spring ephemerals are present; fewest species occur in the fall.

The most extensive oak-hickory forests of the project area are in the Hoosier National Forest and in the transmission corridor area south of the Hancock site. On the Hancock site, they occur on the southern part and on Jeffry Cliff. On the Breckinridge site, these forests cover most of the uplands on the southeastern portion of the site.

The mixed mesophytic communities of the upland hardwood forests are restricted to ravine slopes with deep soils, and are more dependent on favorable habitat conditions than are oak-hickory associations. The deep soils are moist, well drained, and have a thick humus layer and high fertility (SCS 1974).

The mixed mesophytic forest in eastern Kentucky, where it is the climax forest association, typically may be dominated by twenty or more species rather than a few species as is the oak-hickory forest. Yellow poplar, sugar maple, beech, basswood, yellow buckeye, red oak, white oak, red maple, black walnut, black cherry, and white ash are typical dominants (Wharton and Barbour 1973). In transitional western Kentucky, however, the mixed mesophytic forests are not only scattered and more limited, but also have fewer dominant species (Braun 1950). Beech generally is predominant, followed by sugar maple, yellow poplar, white ash, red oak, and white oak.

Favorable habitats for the mixed mesophytic forests are uncommon in the project area, and the ravine slopes surrounding Jeffry Cliff contain the only distinct mixed mesophytic community on either of the potential sites. Land use practices, especially those of the past, have added to the natural restriction of the mixed mesophytic communities by increasing soil loss, leaching, and erosion. The less fertile, drier, post-agricultural or timber harvesting sites favor return of oak-hickory forests rather than the mixed mesophytic types.

3.3.3.1.4 Lowland Hardwoods Forest

Lowland hardoods in the project area are fairly uniform in composition. They are not extensive and often consist of little more than a band of streamside trees. Most stands occur in the Ohio River floodplain and along streams. Interspersed with cultivated areas, they generally occupy poorly drained sites that are too wet for cultivation.

Characteristic species include sycamore, yellow poplar, sweetgum, red maple, boxelder, silver maple, American hornbeam, and black willow. Understory species include boxelder, sugar maple, American hornbeam, hackberry, slippery elm, beech, dogwood, and spicebush.

Ground cover density is variable. Spring flooding tends to bury vegetation and litter with sediment or physically remove it. Subsequent vegetation often appears as dense clumps or aggregated colonies with little litter cover. Generally, the ground cover vegetation follows the expected pattern of low cover in the spring with a rapid increase into the summer and subsequent leveling or decrease in the fall. Colonies of wingstem, lopseed, false nettle, and clearweed are common on periodically flooded silty flats along streams. Herbaceous species in the lowland woods include spring ephemerals and such as mayapple, squirrel corn, spring beauty, jack in the pulpit, and wild ginger. Other common herbs are Virginia creeper, poison ivy, Japanese honeysuckle, cleavers, toothworth, and seedlings of sugar maple, dogwood, American hornbeam, and spicebush.

3.3.3.1.5 Coniferous Forest

Coniferous forests are a minor cover type in most of the project area. The only sizeable stands are in the Hoosier National Forest. These comprise shortleaf pine, white pine, and red pine. Scattered Virginia pine stands occur along ridges and drier slopes of the Hancock transmission corridor. Small plantings of loblolly pine also occur along this corridor.

Most of the coniferous forests in the project area are plantings. During the 1930s and 1940s, the Hoosier National Forest underwent extensive reforestation, and because shortleaf pine was the only species available in large quantities, it was widely planted (USDA Forest Service, personal communication 1980). However, this region is north of the natural range of shortleaf pine and the cold winters have induced stress on many of these pine stands (Subsection 3.3.3.1.8).

Present forest management objectives in the project area are to return to hardwood forests, which is the natural successional trend. Pines are primarily being planted for erosion control (Virginia pine) and reforestation (white pine), with white pine the most commonly planted and valuable coniferous species at this time (Indiana Department of Natural Resources, personal communication 1980).

3.3.3.1.6 Wetlands

The completion of the Cannelton Lock and Dam elevated the Ohio River sufficiently to produce wetland embayments at the mouths of many tributary streams. The Kentucky Department of Fish and Wildlife Resources (1980) has identified 19 such embayments within the Hancock study area (Table 3.3-5). The largest of these wetland embayments are Deer Creek, Millstone Creek, and Bear Creek in Indiana and Town Creek, Bull Creek, and Clover Creek in Kentucky.

One type 3 wetland, which is classified as an inland shallow marsh (U.S. Fish and Wildlife Service 1979), is located west of Tobinsport, Indiana. Two type 5 wetlands, which are identified as inland open fresh water, are located near the Hancock site: Indian Lake and a small lake near Muddy Branch west of highway 1406 (see Figure 3.1-5). One type 6 wetland, classified as a shrub swamp, is found on a small tributary east of Rome, Indiana.

In addition to the embayments, there are numerous ponds, streams, and wet meadows that provide a wetland habitat. The predominant plant species around the ponds are cattails and willows. Marshes and wet meadows vary somewhat in composition, but typical species include scouring rush, smartweed, water pennywort, buttonbush, silver maple, and willows.

Table 3.3-5. Wetlands Embayments Inventoried in the Project Area

	Wetlands				Land Use								
					Urban		Agricultural		Forest		Industrial		
River Mile	Embayment	Nonconnected	Type	Total Acreage	Feet	%	Feet	%	Feet	%	Feet	%	State
699.1		x	6	8.0	0	0	1,057.2	23	3,512.2	77	0	0	Indiana
699.2	x		–	1.3	0	0	0	0	1,056.0	100	0	0	Kentucky
700.9	x		–	86.8	1,076.0	14	3,582.4	46	3,202.8	40	0	0	Kentucky
701.6	x		–	4.8	0	0	3,885.6	100	0	0	0	0	Indiana
703.3	x		–	111.5	0	0	727.8	4	17,796.2	96	0	0	Indiana
703.6	x		–	29.0	0	0	2,122.2	23	6,992.2	77	0	0	Indiana
704.2	x		–	22.3	438.4	6	961.0	13	5,809.6	81	0	0	Indiana
705.1	x		–	2.5	0	0	0	0	2,224.8	100	0	0	Indiana
706.1	x		–	2.0	0	0	929.0	60	618.4	40	0	0	Indiana
707.3	x		–	8.9	0	0	3,108.6	55	2,518.6	45	0	0	Indiana
707.4	x		–	96.0	0	0	9,525.4	37	16,047.6	63	0	0	Kentucky
707.6	x		–	98.1	0	0	781.0	3	28,236.2	97	0	0	Kentucky
710.4	x		–	9.6	0	0	1,941.8	36	3,450.4	64	0	0	Kentucky
710.7	x		–	154.2	908.2	2	22,752.2	51	21.318.0	47	0	0	Kentucky
711.8	x		–	7.1	0	0	0	0	0	0	2,388.0	0	Kentucky
712.3	x		–	23.1	0	0	802.0	9	8,032.2	91	0	0	Kentucky
712.4		x	3	11.7	0	0	4,782.6	82	1,039.0	18	0	0	Indiana
714.5	x		–	16.5	0	0	2,384.2	35	4,435.4	65	0	0	Indiana
717.1	x		–	142.3	1,631.6	5	4,462.0	13	28,320.2	82	0	0	Indiana
718.7	x		–	349.2	8,500.6	10	13,826.6	16	61,891.0	74	0	0	Indiana
719.3	x		–	2.2	249.0	12	1,292.8	64	495.0	24	0	0	Indiana
721.1		x	5	10.0	0	0	493.6	14	3,078.6	86	0	0	Kentucky
721.9		x	5	0.4	297.4	4	0	0	6,960.0	96	0	0	Kentucky

Source: Kentucky Department of Fish and Wildlife Resources (1980).

3.3.3.1.7 Tree Farms

Some small tree farms adjacent to the Hancock site are part of a wood fiber production study being conducted by Willamette Industries and researches from Michigan State University and the University of Kentucky (Wood, Carpenter, and Wittwer 1976). Begun in 1971, the study was undertaken to study yields and cultural practices for American sycamore in the Ohio River Valley in western Kentucky. Preliminary results indicate a high short-rotation fiber yield under intensive culture.

3.3.3.2 Vegetation Stress

Vegetation stress observed in the project area during 1979 and 1980 was caused by a variety of agents, including foiliage and stem insects, diseases, and unfavorable environmental conditions. Stress was documented through use of color infrared aerial photography, field checking (see Section 5.0), and consultation with the Indiana Department of Natural Resources and the USDA Forest Service.

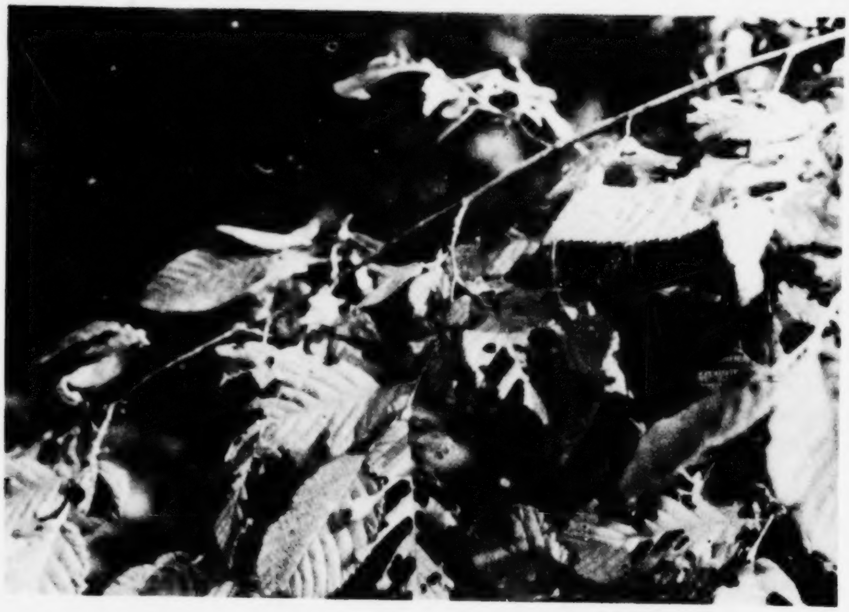
A buildup of insect populations in recent years (especially foliage insects such as the linden looper) has produced stress on several hardwood species in the project area (Figure 3.3-14). Although oaks especially were attacked, elms, hickories, maples, and other hardwoods were also affected. Damage was not generally severe, although spotty mortality of oaks on dry ridges were noted (Indiana Department of Natural Resources, personal communication 1980).

The eastern tent caterpillar was commonly present on black cherry throughout the project area (Figure 3.3-14). Spotty outbreaks of the red oak borer occurred, again more severly on oaks growing on poor, dry ridges. Other insects causing hardwood stress included the bagworm, oak leaftiers, the sugar maple borer, and the twig girdler. The sycamores in the tree farm near the Hancock site had both lacebug and fall webworm infestations (Figure 3.3-14). The fall webworm was also present on black walnut, oaks, sumac, and other hardwood species.

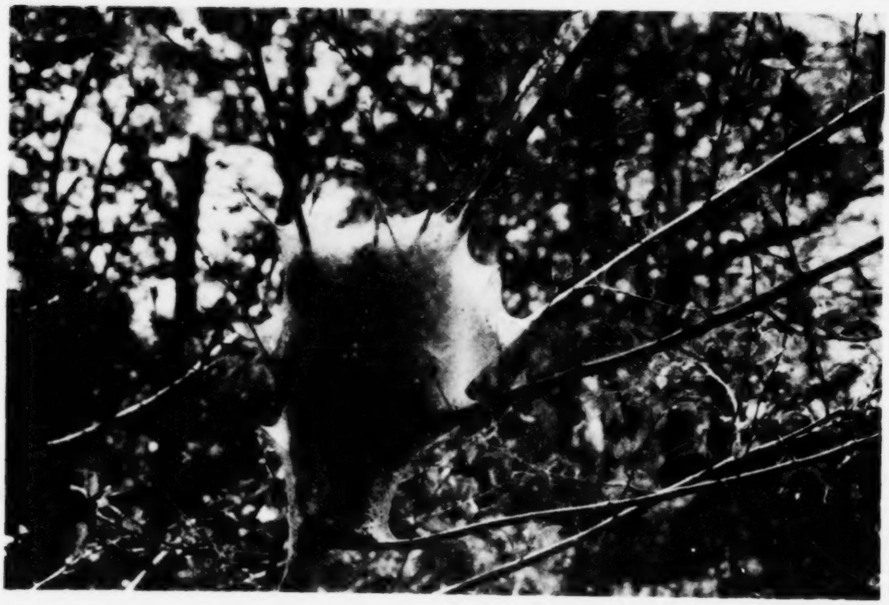
Diseases causing stress in the project area are root diseases (e.g., shoestring rot), leaf diseases (e.g., sycamore anthracnose), wilt diseases (e.g., oak wilt and Dutch elm disease), and diebacks including oak decline and butternut decline. Various galls, particularly on oaks (Figure 3.3-14), were also present.

Conifer stress varied somewhat with the species. The shortleaf pine that was planted extensively thoughout Hoosier National Forest and to a lesser extent throughout the study area is showing damage from recent cold winters. Stress was especially noticeable in areas exposed to high winter winds and in corridors. Winter stress has, in many cases, weakened the shortleaf pines and induced secondary infection from diseases and insects (Figure 3.3-14). The scattered loblolly plantings are also north of their natural range and have shown stress from the cold winters.

Stands of white pine and red pine seem to have fewer problems. Some of the causal agents responsible for minor stress on these species include white pine decline and white pine wilt. In stands of Virginia and shortleaf



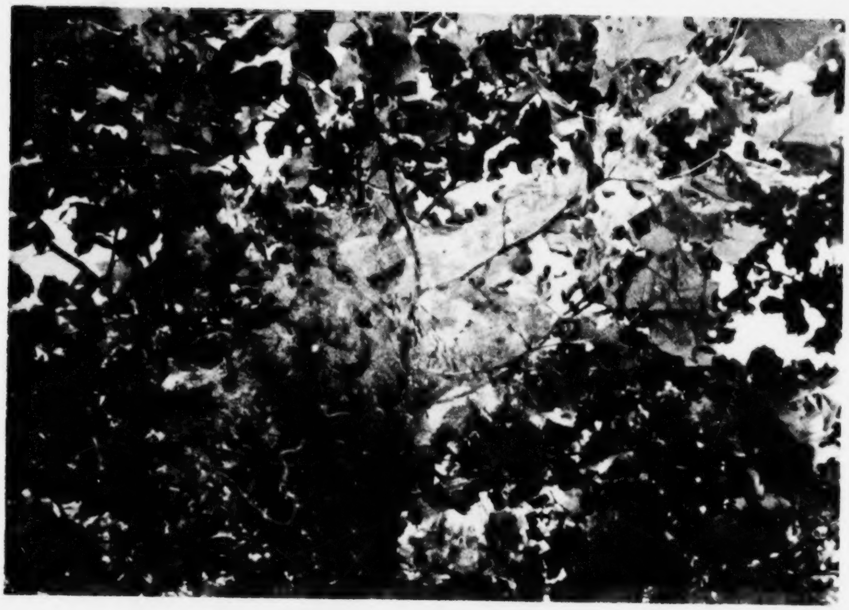
Foliage Insect Stress on Hardwoods



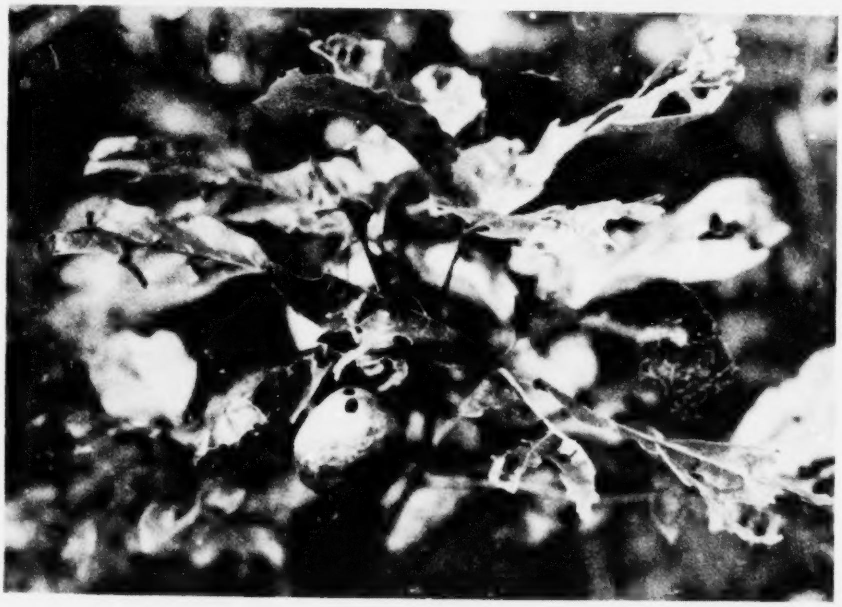
Eastern Tent Caterpillar on Black Cherry

SOURCE: Texas Instruments (1980)

Figure 3.3-14. Examples of Vegetation Stress in the Project Area, 1980 (Sheet 1 of 3)



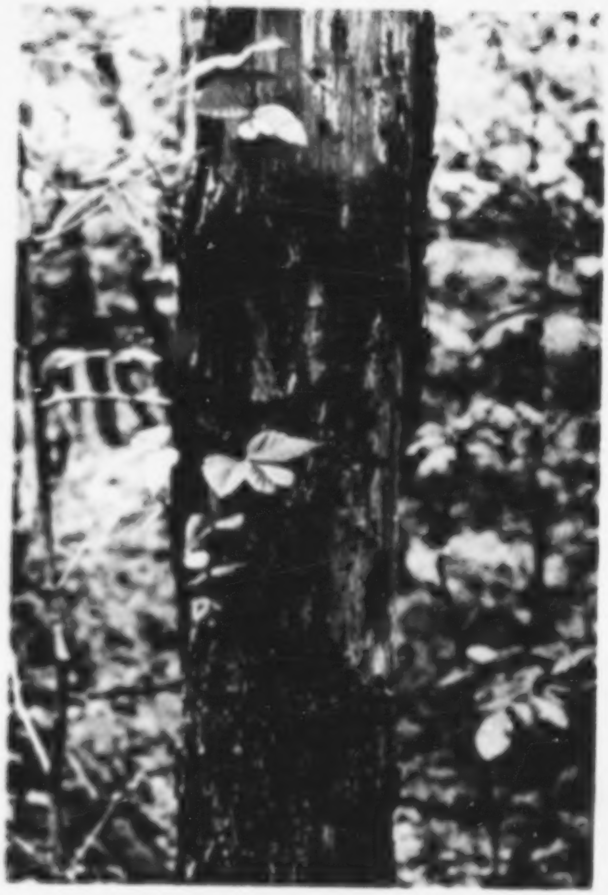
Fall Webworm on Sycamore Adjacent to the Hancock Site



Oak Apple Gall

SOURCE: Texas Instruments (1980)

Figure 3.3-14. Examples of Vegetation Stress in the Project Area, 1980 (Sheet 2 of 3)



Secondary Bark Beetle Infestation
on Winter-Damaged Pine

SOURCE: Texas Instruments (1980)

Figure 3.3-14. Examples of Vegetation Stress in the Project Area, 1980 (Sheet 3 of 3)

pine, the Nantucket tip moth has caused minor stress. Deer browse is a problem in some areas in Hoosier National Forest, especially on young pines. Although there is no present documentation of stress from air pollution, local officials suspect some damage has occurred, particularly to the white pine (Indiana Department of Natural Resources, personal communication 1980).

Figure 3.3-15 shows the locations of specific stress areas present in the project area in 1979 and 1980. Sites where stress was limited to only a few trees or where stress was minor are not shown on the map. Table 3.3-6 keys stress agents to the map.

3.3.3.3 Hancock Site

Vegetation of the Hancock site was sampled during October 1979 and May and July 1980 (see Section 5.0). Major cover types identified on the site and sampled quantitatively were cropland and pasture, upland hardwoods, and lowland hardwoods (see Figure 3.1-12 and Table 3.1-25). Because cultivated fields are primarily monocultures, only the fallow fields were sampled. Minor cover types, which were qualitatively surveyed, included old fields and wetlands. Although some small pine stands have been planted on the Hancock site by a landowner, they occupy such a small portion of the site that they were not considered distinct cover types.

3.3.3.3.1 Cropland and Pasture

No tree or shrub stratum was present in the fallow field sampling locations. Seasonal data for the herbaceous cover stratum are in Table 3.3-7. The most important species throughout the year are grasses and sedges, especially fescue. Lespedezas and clovers are among the consistent forb components of the fallow field.

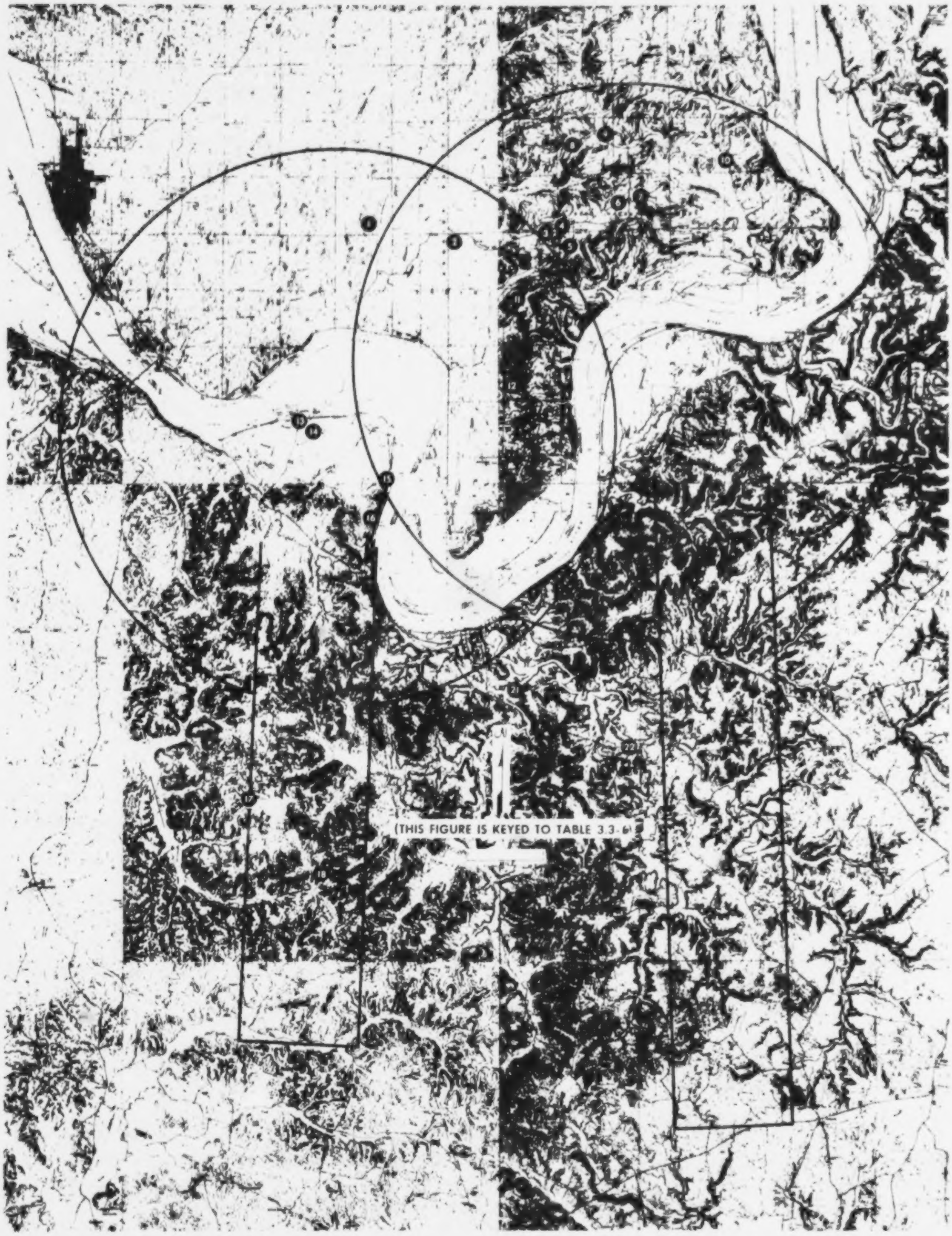
The number of species present increases from May to October. Particularly noticeable is the increase in composites, especially goldenrod, calico aster, mistflower, and boneset. Grasses also increse in dominance from spring to fall. Important grass and sedge species in October include broom sedge, nut grsss, and foxtail grass.

Vegetation cover in the fallow fields is considerably greater than litter cover. Vegetation density was greatest on the site.

3.3.3.3.2 Old Fields

Eastern redcedar is the most common woody species in the old fields cover type. Other important trees include sassafras, black locust, sweetgum, white ash, winged elm, and smooth sumac. Minor tree species include dogwood, yellow poplar, silver maple, and black cherry.

Japanese honeysuckle and greasses are the major ground cover species. Common forbs are goldenrod, black-eyed Susan, Queen Anne's lace, morning glory, daisy fleabane, rose-pink, narrow-leaved mountain mint, hairy vetch, ragweed, and chickory. Common shrubs are blackberry and wild rose.


(THIS FIGURE IS KEYED TO TABLE 3.3-6)
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SOURCE· Texas Instruments (1980)

Figure 3.3-15. Areas of Vegetation Stress, Project Area, 1979-1980

Table 3.3-6. Vegetation Stress Causal Agents and Species Affected, Project Area, 1979-1980

Map Unit	Species Affected	Causal Agent(s)
1	Black cherry	Tent caterpillar
2	Oaks, elms	Linden looper
3	Shortleaf pine	Winter stress, secondary bark beetle infestation
4	Shortleaf pine	Winter stress
5	Hardwoods	Timber removal
6	Shortleaf pine	Winter stress, secondary bark beetle infestation
7	Shortleaf pine	Winter stress, secondary bark beetle infestation
8	Shortleaf pine	Winter stress
9	White pine	Pine bark beetle
10	Shortleaf pine	Winter stress
11	Shortleaf pine	Winter stress
12	Shortleaf pine Hardwoods	Winter stress Timber removal
13	Sycamore	Lacebug, fall webworm
14	Elms, maples	Linden looper
15	Shortleaf pine	Winter stress
16	Oaks, hickories, elms, maples Black cherry, oaks, sumac, black walnut	Linden looper Fall webworm
17	Black cherry Loblolly pine	Tent caterpillar Winter stress
18	Hardwoods (along transmission corridor)	Herbicides
19	Sycamore, walnut, black cherry	Fall webworm
20	Oaks, elms, maples	Linden looper
21	Hardwoods (along transmission corridor)	Herbicides
22	Hardwoods (along transmission corridor)	Herbicides

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.3-7. Species Composition, Relative Values, and Importance Values for Herbaceous Stratum, Fallow Field Cover Type, Hancock Site, 1979-1980

	October				May				July			
	Relative (%)			Importance Value*	Relative (%)			Importance Value*	Relative (%)			Importance Value*
Taxa	Cover	Density	Frequency		Cover	Density	Frequency		Cover	Density	Frequency	
Agrimonia parviflora									0.1	1.3	1.7	3.1
Ambrosia artemisiifolia	0.1	0.1	1.2	1.4	0.1	0.1	2.2	2.4	7.2	3.4	8.3	18.9
Andropogon virginicus	7.5	4.2	8.3	20.0**								
Aster lateriflorus	1.7	1.6	4.8	8.1								
Asteraceae (3 spp.)					1.6	1.3	11.0	13.9				
Bidens bipinnata	4.4	0.7	4.8	9.9								
Campsis radicans	0.3	0.1	1.2	1.6								
Cerastium vulgatum					0.3	0.1	4.4	5.0				
Cinna arundinacea									0.3	0.2	1.7	2.2
Cyperus esculentus	21.0	23.7	8.3	53.0**								
Desmodium perplexum	0.5	0.3	3.6	4.4					1.0	0.7	5.0	6.7
Digitaria filiformis	1.0	1.4	2.4	4.8								
Eleocharis sp.	0.7	10.1	1.2	12.0	2.9	0.1	2.2	5.2				
Erechtites hieracifolia	0.1	0.1	1.2	1.4								
Erigeron philadelphicus									0.3	0.2	1.7	2.2
Eupatorium colestinum	1.7	2.4	4.8	8.9								
Eupatorium perfoliatum	3.3	0.1	1.2	1.6								
Euphorbia maculata	0.6	0.4	4.8	5.8								
Fabaceae	0.1	0.2	2.4	2.7								
Festuca sp.					72.8	70.9	22.2	165.9**	49.5	31.7	16.7	97.9**
Fraxinus americana									0.2	0.1	1.7	2.0
Lespedeza cuneata	0.1	0.4	2.4	2.9								
Lespedeza sp.					0.7	1.1	6.7	8.5	21.5	52.6	11.7	85.8**
Panicum sp.	1.1	1.4	3.6	6.1								
Philadelphus hirsutus	0.1	0.1	1.2	1.4								
Plantago lanceolata									3.6	1.8	5.0	10.4
Plantago rugelii					0.1	0.1	2.2	2.4	0.2	0.1	1.7	2.0
Plantago virginica					0.2	0.4	6.7	7.3				
Poaceae	36.8	33.5	7.1	77.4**	5.1	1.8	20.0	26.9**				
Polygala sanguinea					0.3	0.4	3.3	4.0				
Prenanthus sp.	0.4	0.2	1.2	1.8								
Prunella vulgaris									0.3	0.2	1.7	2.2
Pycnanthemum tenuifolium									1.8	1.5	3.3	6.6
Rhus radicans					0.1	0.1	1.7	1.9				
Rubiaceae									0.1	0.2	3.3	3.6
Rubus allegheniensis					0.6	0.2	4.4	5.2	2.0	0.5	3.3	5.8
Rudbeckia hirta					0.3	0.4	3.3	4.0				
Setaria sp.	11.0	11.7	6.0	28.7**					0.3	0.5	3.3	4.1
Solanum carolinense	1.6	1.2	7.1	9.9					0.3	0.4	3.3	4.0
Solidago altissima	4.1	1.6	4.8	10.5								
Solidago sp.									0.7	0.4	3.3	4.4
Sorghum halepense	0.1	0.4	2.4	2.9								
Sparganium sp.	0.1	0.2	2.4	2.7								
Trifolium pratense									0.3	0.2	1.7	2.2
Trifolium repens									2.2	1.8	5.0	9.0
Trifolium sp.	1.1	3.2	4.8	9.1	15.7	23.6	15.6	54.9**				
Verbena hastata									0.3	0.1	1.7	2.1
Veronia fasciculata	0.3	0.6	6.0	6.9					6.8	1.0	6.7	14.5
Xanthium strumarium	0.1	0.1	1.2	1.4	0.1	0.1	2.2	2.4				

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*Importance value = relative cover + relative density + relative frequency.

**Major species (importance value ≥20).

Source: Texas Instruments Incorporated field data (1979-1980).

3.3.3.3.3 Upland Hardwoods Forest

Data collected on the tree stratum of the Hancock site upland hardwoods are in Table 3.3-8. Seasonal data for the shrub and herbaceous strata are in Tables 3.3-9 and 3.3-10.

The upland hardwoods cover type comprises approximately 20% of the Hancock site, primarily around Jeffry Cliff and the southeastern portion. Just as the ravine slopes surrounding Jeffry Cliff (especially those to the southeast) contain the only distinct mixed mesophytic hardwood association, the top of Jeffry Cliff appears to be the only distinct oak-hickory association. Much of the rest of the forest on the southeastern portion of the site is transitional, having components of both the oak-hickory and mixed mesophytic associations. Because the sampling transects for the upland hardwood cover type traversed various associations from Jeffry Cliff through much of the transistional hardwoods, data reflect a composite of the component forest communities.

Important trees in the composite upland hardwoods are sugar maple, hickory, beech, scarlet oak, chinkapin oak, northern red oak, and slippery elm. The hickories and the oaks, especially scarlet and chinkapin, are important on top of Jeffry cliff. Beech is important on the ravine slopes and its high importance value reflects the presence of a distinct mixed mesophytic association. Sugar maple, which had the highest importance value, is a component of both the distinct mixed mesophytic and oak-hickory associations and of the transitional upland hardwood forest as well.

Table 3.3-8. Species Composition, Relative Values, and Importance Values for Tree Stratum, Upland Hardwoods Cover Type, Hancock Site, 1979

Species	Relative (%) Cover	Frequency	Density	Importance Value*
Acer rubrum	0.2	1.1	0.6	1.9
Acer saccharum	8.6	18.8	21.0	48.4**
Carya ovata	4.1	4.6	3.8	12.5
Carya sp.	17.1	1.1	6.3	24.5**
Celtis occidentalis	1.4	3.5	2.2	7.1
Cercis canadensis	0.1	1.1	0.6	1.7
Cornus florida	0.2	3.5	2.2	5.9
Diospyros virginiana	2.5	2.5	1.6	6.6
Fagus grandifolia	15.3	6.0	6.9	28.2**
Fraxinus americana	4.3	3.5	3.1	10.9
Juniperus virginiana	0.2	2.5	1.6	4.3
Liquidambar styraciflua	5.0	2.5	5.3	12.8
Liriodendron tulipifera	2.9	4.6	5.3	12.8
Morus rubra	0.5	4.6	3.1	8.2
Quercus alba	1.8	2.5	2.2	6.5
Quercus coccinea	0.7	1.1	0.6	2.4
Quercus muehlenbergii	8.6	7.1	6.9	22.6**
Quercus rubra	15.1	9.6	6.9	31.6**
Robinia pseudoacacia	6.8	8.2	8.5	23.5**
Sassafras albidum	1.4	2.5	2.2	6.1
Ulmus rubra	3.6	9.6	9.1	22.3**

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*Importance value = relative cover + relative frequency + relative density.

**Major species (importance value ≥20).

Source: Texas Instruments Incorporated field data (1979).

Table 3.3-9. Species Composition, Relative Values, and Importance Values for Shrub Stratum, Upland Hardwoods Cover Type, Hancock Site, 1979-1980

Taxa	October				May				July			
	Relative (%)			Importance Value*	Relative (%)			Importance Value*	Relative (%)			Importance Value*
	Cover	Density	Frequency		Cover	Density	Frequency		Cover	Density	Frequency	
Acer saccharum	34.1	30.7	24.0	88.8**	35.6	17.5	28.3	81.4**	53.2	32.0	23.3	108.5**
Asimina triloba									1.7	4.0	5.9	11.6
Carpinus caroliniana					1.7	2.5	7.2	11.4				
Carya ovata					8.5	27.5	7.2	43.2**	1.7	4.0	5.9	11.6
Carya sp.	2.7	3.0	6.8	12.5								
Celtis occidentalis	4.3	4.0	6.8	15.1								
Cercis canadensis	1.6	2.0	3.5	7.1					1.7	4.0	5.9	11.6
Cornus florida	0.3	1.0	3.5	4.8	10.2	7.5	14.3	32.0**				
Euonymus americanus	0.5	3.0	6.8	10.3								
Fagus grandifolia	1.6	2.0	3.5	7.1	16.9	5.0	14.3	36.2**				
Fraxinus americana	1.6	1.0	3.5	6.1	0.8	5.0	7.2	13.0	23.3	16.0	11.8	51.1**
Hydrangea arborescens					8.5	27.5	7.2	43.2**	3.3	8.0	5.9	17.2
Lindera benzoin									1.7	4.0	5.9	11.6
Liriodendron tulipifera	13.3	10.9	3.5	27.7**	0.8	2.5	7.2	10.5				
Morus rubra	5.3	3.0	10.4	18.7								
Oxydendron arboreum	16.0	21.8	6.8	44.6**								
Prunus serotina									1.7	4.0	5.9	11.6
Quercus muehlenbergii	14.4	11.9	10.4	36.7**					0.3	4.0	5.9	10.2
Quercus rubra									3.3	8.0	5.9	17.2
Sassafras albidum	1.6	2.0	3.5	7.1								
Ulmus rubra	2.7	4.0	6.8	13.5	16.9	5.0	7.2	29.1**	8.3	12.0	17.4	37.7**

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*Importance value = relative cover + relative density + relative frequency.

**Major species (importance value ≥20).

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.3-10. Species Composition, Relative Values, and Importance Values for Herbaceous Stratum, Upland Hardwoods Cover Type, Hancock Site, 1979-1980

Taxa	October				May				July			
	Relative (%)			Importance Value*	Relative (%)			Importance Value*	Relative (%)			Importance Value*
	Cover	Density	Frequency		Cover	Density	Frequency		Cover	Density	Frequency	
Acer saccharum	3.6	0.5	9.0	13.1	7.3	2.8	5.2	15.3	1.2	3.4	2.7	7.3
Actaea pachypoda					0.9	0.7	0.9	2.5				
Arisaema dracontium									2.3	2.5	2.7	7.5
Arisaema triphyllum					4.1	4.5	6.9	15.5				
Asplenium platyneuron									2.9	3.4	5.7	12.0
Boehmeria cylindrica									3.5	5.0	5.7	14.2
Botrychium virginianum					0.9	0.7	1.7	3.3				
Carex sp.					0.5	0.7	0.9	3.4	1.2	1.7	2.7	5.6
Carpinus caroliniana					0.1	0.3	0.9	1.3				
Carya ovata					0.5	0.7	0.9	2.1	0.8	2.5	4.2	7.5
Carya sp.	10.1	0.4	3.2	13.7	0.6	1.0	2.6	4.2	1.7	1.7	2.7	6.1
Cercis canadensis	1.2	0.4	3.2	4.8								
Chimaphila maculata									0.6	1.7	1.5	3.8
Claytonia virginica					1.4	2.1	2.6	6.1				
Cornus florida					5.4	1.4	1.7	8.5	1.2	0.8	1.5	3.5
Dentaria heterophylla					0.3	1.4	2.6	4.3				
Dentaria laciniata					3.6	16.2	10.4	30.2**				
Dicentra cucullaria					9.0	7.6	1.7	18.3				
Dicotyledonae	2.4	36.2	5.9	44.5**								
Dryopteris marginalis					1.4	0.7	1.7	3.8	11.5	1.7	2.7	15.9
Euonymus americanus									0.1	1.7	1.5	3.3
Eupatorium rugosum	4.8	1.1	9.0	14.9								
Fabaceae	0.2	0.4	3.2	3.8								
Fagus grandifolia					0.9	0.7	1.7	3.3				
Fraxinus americana					0.1	0.3	0.9	1.3	4.0	4.2	7.0	15.2
Galium aparine					0.6	1.4	2.6	4.6				
Galium circaezans									1.4	5.0	5.7	12.1
Hydrangea arborescens					1.0	1.0	1.7	3.7				
Lindera benzoin					0.1	0.3	0.9	1.3				
Lonicera japonica	62.0	55.3	18.0	135.3**	1.9	8.3	2.6	12.8				
Morus rubra					0.1	0.3	0.9	1.3				
Osmorhiza claytonii	1.2	2.2	9.0	12.4	0.9	1.0	1.7	3.6				
Oxalis violacea					0.9	3.8	0.9	5.6				
Parthenocissus quinquefolia					10.6	8.3	9.5	28.4**	27.7	23.5	15.4	66.6**
Phryma leptostachya					4.6	4.5	1.7	10.8				
Pilea pumila	2.4	0.7	5.9	9.0					1.2	1.7	1.5	4.4
Podophyllum peltatum					15.4	3.4	5.2	24.0**	1.2	1.7	1.5	4.4
Polygonatum biflorum					0.5	0.7	0.9	2.1	3.9	3.4	2.7	10.0
Polystichum acrostichoides					1.8	1.0	1.7	4.5				
Prunus serotina					0.5	0.7	0.9	2.1				
Quercus alba									0.6	0.8	1.5	2.9
Quercus muehlenbergii	2.0	0.4	3.2	5.6					1.2	1.7	2.7	5.6
Quercus prinus					0.5	0.3	0.9	1.7				
Quercus rubra					0.5	0.3	0.9	1.7	3.5	3.4	4.2	11.1
Ranunculus recurvatus					0.1	0.3	0.9	1.3				
Ranunculus sp.	1.2	0.4	3.2	10.4								
Rhus radicans					7.4	7.6	6.1	21.1**	9.6	18.5	12.7	40.8**
Rubus allegheniensis	1.2	0.2	3.2	4.6								
Sassafras albidum									0.6	0.8	1.5	2.9
Silene virginica					0.1	0.3	0.9	1.3				
Smilacina racemosa					1.8	1.4	1.7	4.9	5.8	1.7	1.5	9.0
Smilax hispida	2.4	1.1	9.0	12.5	0.2	1.0	1.7	15.4	5.8	1.7	1.5	9.0
Solidago altissima	2.0	0.2	3.2	5.4								
Tilia americana					4.5	0.7	0.9	6.1	1.2	1.7	2.7	5.6
Trillium sessile					0.9	0.7	0.9	2.5				
Ulmus rubra	3.2	0.7	12.2	16.1	7.9	9.0	7.8	24.7**	8.1	5.0	4.2	17.3
Viola sororia					0.5	1.7	2.6	4.8	0.6	0.8	1.5	2.9

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*Importance value = relative cover + relative density + relative frequency.

**Major species (importance value ≥20).

Source: Texas Instruments Incorporated field data (1979-1980).

Predominant species in the upland hardwoods shrub stratum are sugar maple, American hornbeam, dogwood, beech, white ash, wild hydrangea, yellow poplar, sourwood, chinkapin oak, and slippery elm. Most of these species are saplings of shade-tolerant members of the overstory. Sugar maple again had the highest importance value. Wild hydrangea, spice bush, pawpaw, strawberry bush, and American hornbeam are indicators of a moist, rich habitat typical of a mixed mesophytic forest.

Common spring ephemerals in the herb stratum include mayapple, jack in the pulpit, toothwort, Dutchman's breeches, and spring beauty. Other important herbs are Japanese honeysuckle, Virginia creeper, poison ivy, and seedlings of hickory and slippery elm. Species not present in the sampling plots but indicative of specific associations include phacelia, which is common on the slopes of Jeffry Cliff, and Sullivantia, which is common in moist, shady pockets on the sandstone face of Jeffry Cliff. Other typical mixed mesophytic herbaceous species around Jeffry Cliff are trillium, white baneberry, spring beauty, Dutchman's breeches, and numerous ferns, especially marginal shield-fern. Species observed in the drier oak-hickory forests on top of Jeffry Cliff include pussy-toes, Virginia creeper, poison ivy, and prickly pear cactus.

Ground cover in the Hancock site's upland hardwoods shows little disturbance except near transmission corridors that are used for livestock grazing. Ground cover in locations not used as cattle loafing areas reflect shrub and tree cover. Areas with comparatively little overstory and understory cover have a higher percent ground cover. Litter cover is influenced by topography and herbaceous cover. Areas with dense herbaceous cover have little litter cover. Sites with steeper slopes have less litter cover and a higher percent of bare ground.

3.3.3.3.4 Lowland Hardwoods Forest

Data collected in October 1979 for the tree stratum in the lowland hardwoods are shown in Table 3.3-11. Seasonal data for the shrub and herbaceous strata are in Tables 3.3-12 and 3.3-13.

The most important overstory species in the lowland hardwoods cover type on the Hancock site is yellow poplar, followed by sycamore, sweetgum, American hornbeam, and red maple. Although yellow poplar is the most abundant species, sycamore generally is larger, with one tree having a diameter at breast height (dbh) of 36 inches.

Important species in the lowland hardwoods shrub stratum are red maple, sugar maple, American hornbeam, bitternut hickory, dogwood, white ash, spicebush, yellow poplar, and white oak. Spicebush is the most consistently important shrub species.

Several of the important herbaceous species in the spring are ephemerals either not present or of less importance later in the growing season, including spring beauty, squirrel corn, and cleavers. However, spring ephemerals are not as abundant in the lowland hardwoods as in the upland hardwoods. In the lowland type, the greatest number of herb species was present in July rather than May. Although partly due to spring flooding, the increased ground cover development in July is primarily due to the increasing importance of species such as wingstem, lopseed, and clearweed which grow in dense aggregated

Table 3.3-11. Species Composition, Relative Values, and Importance Values for Tree Stratum, Lowland Hardwoods Cover Type, Hancock Site, 1979

Species	Relative (%) Cover	Relative (%) Frequency	Relative (%) Density	Importance Value*
Acer negundo	0.3	2.6	1.7	4.6
Acer rubrum	1.0	11.1	10.8	22.9**
Acer saccharum	0.2	2.6	1.7	4.5
Carpinus caroliniana	2.4	11.1	14.2	27.7**
Carya sp.	0.2	2.6	1.7	4.5
Celtis occidentalis	0.8	4.8	3.3	8.9
Diospyros virginiana	0.4	1.1	0.8	2.3
Fagus grandifolia	7.8	4.8	5.0	17.6
Fraxinus americana	5.9	6.3	4.2	16.4
Liriodendron tulipifera	18.1	21.1	28.3	67.5**
Liquidambar styraciflua	8.0	17.4	15.8	41.2**
Platanus occidentalis	46.0	4.8	4.2	55.0**
Quercus muehlenbergii	0.2	1.1	0.8	2.1
Quercus rubra	0.7	3.7	2.5	6.9
Ulmus americana	14.4	4.8	5.0	17.7

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*Importance value = relative cover + relative frequency + relative density.

**Major species (importance value ≥20).

Source: Texas Instruments Incorporated field data (1979).

colonies. Other common herbs in the lowland woods include Virginia creeper, poison ivy, and Japanese honeysuckle, which dominates areas of open canopy.

As in the upland woods, herbaceous cover and density are related to overstory and understory cover. However, another factor in the lowland hardwoods is spring flooding, which initially reduces streamside vegetation and litter cover, although later vegetation cover is often more dense than in nonflooded areas.

3.3.3.3.5 Wetlands and Water Bodies

None of the wetlands inventoried by the Kentucky Department of Fish and Wildlife Resources (Table 3.3-5) are within the boundaries of the Hancock site, although one Type 5 wetland is associated with Indian Creek and another is associated with Muddy Branch. The latter wetland, which is located just west of the site (see Figure 3.1-6), contains an abundance of cattail. Vegetation of several small ponds located within the Hancock site boundaries also is predominantly cattail, although scouring rushes and willows are present.

Table 3.3-12. Species Composition, Relative Values, and Importance Values for Shrub Stratum, Lowland Hardwoods Cover Type, Hancock Site, 1979-1980

	October				May				July			
	Relative (%)			Importance Value*	Relative (%)			Importance Value*	Relative (%)			Importance Value*
Taxa	Cover	Density	Frequency		Cover	Density	Frequency		Cover	Density	Frequency	
Acer negundo	2.3	3.8	9.5	15.5								
Acer rubrum	14.7	6.7	9.5	30.9**	2.4	6.9	8.3	17.6				
Acer saccharum	32.6	25.7	9.5	67.8**	26.1	10.3	16.7	53.1**	11.6	11.4	19.5	42.5**
Actinomeris alternifolia									1.8	2.9	6.5	11.2
Asimina triloba									8.9	5.7	2.3	16.9
Carpinus caroliniana	4.7	3.8	9.5	18.0	4.7	6.9	8.3	19.9	17.9	5.7	6.5	30.1**
Carya cordiformis	2.3	11.4	9.5	23.2**								
Celtis occidentalis	7.0	1.9	9.5	18.4								
Cornus florida	1.2	1.9	4.8	7.9					8.9	5.7	6.5	21.1**
Fagus grandifolia	1.2	1.9	4.8	7.9								
Fraxinus americana									4.5	11.4	19.5	35.4**
Lindera benzoin	34.9	4.8	19.0	58.7**	61.6	65.5	41.7	168.8**	26.8	42.9	19.5	89.2**
Liriodendron tulipifera	7.0	5.7	4.8	17.5	2.4	3.4	8.3	14.1	10.7	8.6	13.0	32.3**
Prunus serotina					0.5	3.4	8.3	12.2				
Quercus alba									8.9	5.7	6.5	21.1**
Quercus muehlenbergii					2.4	3.4	8.3	14.1				
Quercus rubra	1.2	1.9	4.8	7.9								
Sassafras albidum	1.2	10.5	4.8	16.5								

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*Importance value = relative cover + relative density + relative frequency.

**Major species (importance value ≥20).

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.3-13. Species Composition, Relative Values, and Importance Values for Herbaceous Stratum, Lowland Hardwoods Cover Type, Hancock Site, 1979-1980

Taxa	October				May				July			
	Relative (%)			Importance Value*	Relative (%)			Importance Value*	Relative (%)			Importance Value*
	Cover	Density	Frequency		Cover	Density	Frequency		Cover	Density	Frequency	
Acer negundo									0.7	0.3	1.0	2.0
Acer rubrum									0.3	0.5	1.0	1.8
Acer saccharum	9.1	2.4	6.5	18.0	3.8	1.1	2.7	7.6	15.4	2.9	6.9	25.2**
Actinomeris alternifolia									4.2	3.4	1.9	9.5
Agrimonia mollis					1.2	1.4	2.7	5.3	0.3	0.3	1.0	1.6
Allium canadense					0.7	5.7	4.5	10.9				
Arisaema triphyllum									1.0	0.8	1.9	3.7
Asimina triloba									0.7	0.1	1.9	2.7
Asplenium platyneuron									0.4	0.5	1.9	2.8
Botrychium obliquum	0.6	0.6	1.7	2.9								
Carex sp.	2.3	3.0	6.5	11.8	7.3	3.7	1.8	12.8	2.8	2.1	5.9	10.8
Carpinus caroliniana	1.1	2.4	3.1	6.6	0.1	0.9	1.8	2.9	0.4	0.5	1.9	2.8
Carya cardiformis	1.1	1.2	3.1	5.4								
Cercis canadensis									0.3	0.3	1.9	2.5
Cinna arundinaceae	0.6	1.2	1.7	3.5								
Claytonia virginica					5.0	8.5	6.5	20.0**				
Compositae	0.6	0.6	1.7	2.9								
Cornus florida					0.1	0.3	3.6	4.0				
Cystopteris fragilis									0.3	0.5	1.0	1.8
Dicentra canadensis					21.3	16.2	9.9	47.4**				
Dioscorea quanternata									3.5	0.8	1.0	5.3
Erythronium americanum					0.7	0.9	0.9	2.5				
Eupatorium rugosum	1.1	2.4	3.1	6.6								
Fraxinus americana					0.1	0.6	1.8	2.5	0.1	0.3	1.0	1.4
Galium aparine					2.6	7.7	9.9	20.2**				
Geum canadense	3.4	4.2	8.0	15.6					2.0	2.9	6.9	11.8
Lindera benzoin	2.3	1.8	3.1	7.2	0.8	0.6	1.8	3.2	6.6	2.9	6.9	16.4
Liquidambar styraciflua	0.6	0.6	1.7	2.9					1.4	0.5	1.9	3.8
Liriodendron tulipifera	0.6	0.6	1.7	2.9					0.7	0.5	1.0	2.2
Lonicera japonica	57.1	52.4	21.0	187.6**	27.7	18.2	10.8	56.7**	29.3	29.6	9.8	68.7**
Nyssa sylvatica									0.7	0.5	1.0	2.2
Oxalis stricta					1.5	4.3	2.7	8.5				
Parthenocissus quinquefolia					2.0	3.1	6.4	11.5	6.4	4.5	11.7	22.6**
Phryma leptostachya					16.5	13.4	5.4	35.3**	2.4	3.1	5.9	11.4
Pilea pumila	0.6	0.6	1.7	2.9					0.4	0.8	1.9	3.1
Poaceae					3.4	4.0	7.2	14.6	4.9	3.9	2.9	11.7
Podophyllum peltatum					0.7	0.6	0.9	2.2				
Polygonum virginianum	2.3	3.0	4.8	10.1	0.2	0.9	2.7	3.8	0.8	0.8	1.9	3.5
Polystichum acrostichoides	2.3	3.6	6.5	12.4								
Prunus serotina					0.5	1.4	2.7	4.6	0.1	0.3	1.0	1.4
Quercus alba									0.1	0.3	1.0	1.4
Quercus rubra	0.6	0.6	1.7	2.9								
Rhus radicans	6.9	3.6	9.6	20.1**	2.1	4.6	8.1	14.8	9.1	7.3	9.8	26.2**
Sambucus canadensis	1.1	2.4	3.1	6.6								
Sanguinaria canadensis	0.6	0.6	1.7	2.9								
Sassafras albidum	2.3	4.2	3.1	9.6								
Sedum ternatum	2.3	7.1	3.1	12.5					3.5	26.2	1.0	30.7**
Smilax hispida	0.6	1.2	1.7	3.5								
Smilax sp.					0.4	0.3	0.9	1.6				
Trillium sessile					0.1	0.3	0.9	1.3				
Viola papilionacea					1.0	1.4	3.6	6.0				
Viola sororia									1.1	1.8	4.8	7.7

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*Importance value = relative cover + relative density + relative frequency.

**Major species (importance value ≥20).

Source: Texas Instruments Incorporated field data (1979-1980).

Inside the northern boundary of the site is a small (about 4 acres when flooded) wetland (see Figure 3.1-6) that has not been inventoried by the Commonwealth of Kentucky. Predominant vegetation includes smartweed, buttonbush, silver maple, and willows. Although decreasing in size through the summer, shallow water covers at least 1 acre year-round.

3.3.3.4 Hancock Transmission Corridor

The predominant vegetation type on the Hancock corridor is upland hardwoods. Oak-hickory forests are widespread on the hilly, rugged topography. Prominent upland hardwood species are white oak, northern red oak, shagbark hickory, black cherry, slippery elm, sugar maple, yellow poplar, sassafras, sweetgum, redbud, and dogwood.

Lowland hardwoods are usually restricted to small bands along streams. Common species include sycamore, willows, and some sweetgum and yellow poplar.

Coniferous forests are scattered along the corridor. Naturally occurring stands are usually composed of Virginia pine. Small stands of loblolly pine have been planted by landowners.

In most of the old fields along the corridor, eastern redcedar and sassafras are predominant. Other common species are smooth sumac, Virginia pine, winged elm, sweetgum, and silver maple.

Vegetation stress was present during the 1979-1980 survey. Much of it was due to herbicide use on existing corridors and to timber cutting. Winter stress on loblolly pine was also evident. Damage to hardwoods from eastern tent caterpllars, linden loopers, and other insects was typical of the project area.

3.3.3.5 Breckinridge Site

Vegetation on the Breckinridge site was also sampled during October 1979 and May and July 1980. Survey methods and cover types sampled were the same as on the Hancock site. Cover types of the Breckinridge site and their extent are shown in Figure 3.1-15 and Table 3.1-27.

3.3.3.5.1 Cropland and Pasture

Seasonal data for the fallow field cover type, which contains only a herbaceous stratum, are in Table 3.3-14. Sites and species characteristics are similar to the Hancock site. Species with highest importance values are fescue, forked rush, goldenrods, crab grass, bearded shorthusk, lespedeza, ragweed, and buttonweed. Vegetation cover is extensive; plant density is greatest on the site; and litter cover and bare ground are sparse.

3.3.3.5.2 Old Fields

This minor cover type on the Breckinridge site is similar to that on the Hancock site.

Although species composition and dominance varies depending on successional stage, predominant tree species are smooth sumac, eastern redcedar,

Table 3.3-14. Species Composition, Relative Values, and Importance Values for Herbaceous Stratum, Fallow Field Cover Type, Breckinridge Site, 1979-1980

Taxa	October				May				July			
	Relative (%)			Importance Value*	Relative (%)			Importance Value*	Relative (%)			Importance Value*
	Cover	Density	Frequency		Cover	Density	Frequency		Cover	Density	Frequency	
Acer negundo	0.1	0.1	2.0	2.2								
Achillea millefolium					0.4	0.2	4.7	5.3	0.4	0.4	2.6	3.4
Ambrosia artemisifolia	8.7	4.2	10.0	22.9**								
Aristida sp.	0.1	0.1	2.0	2.2								
Asteraceae					0.1	0.2	2.3	2.6				
Aster lateriflorus	1.6	1.2	10.0	12.8								
Brachyelytrum erectum					12.6	8.8	11.6	33.0**				
Carex pennsylvanica					0.3	0.2	2.3	2.8				
Cinna arundinacea					1.0	0.2	4.7	5.9				
Cirsium vulgare	0.7	0.1	2.0	2.8								
Daucus carota									0.6	0.5	5.3	6.4
Desmodium paniculatum	2.1	2.2	8.0	12.3								
Digitaria filiformis	12.6	16.6	4.0	33.2**								
Diodia teres	5.7	15.0	2.0	22.7**								
Erigeron strigosus									0.2	0.2	2.6	3.0
Eupatorium coelestinum	0.7	0.1	2.0	2.8					8.1	0.7	5.3	14.1
Eupatorium rugosum	0.1	0.1	2.0	2.2								
Eupatorium sp.	0.9	0.9	4.0	5.8								
Festuca sp.					70.0	67.4	20.9	158.3**	66.5	67.6	26.3	160.4**
Gnaphalium obtusifolium	0.2	0.1	4.0	4.3								
Houstonia sp.					0.5	9.2	4.7	14.4				
Juncus dichotomus	41.3	48.3	10.0	99.6**								
Juniperus virginiana	0.7	0.1	2.0	2.8								
Lespedeza sp.					1.3	2.3	11.6	15.2	2.4	18.3	5.3	26.0**
Liquidambar styraciflua	0.1	0.1	2.0	2.2	0.1	0.1	2.3	2.5				
Lonicera japonica					7.0	8.3	2.3	17.6	0.6	0.5	5.3	6.4
Oxalis stricta					0.7	0.9	2.3	4.6	0.0	0.2	2.6	2.8
Plantago virginica					0.4	0.3	4.7	6.4				
Poaceae					0.4	0.3	4.7	5.4				
Prunella vulgaris									0.2	0.4	2.6	3.2
Rubus allegheniensis					0.3	0.1	2.3	2.7	4.0	2.0	7.6	8.1
Rudbeckia hirta									0.2	0.2	2.6	3.0
Rumex acetosella					0.3	0.2	2.3	2.8				
Schizachne purpurascens	2.1	4.0	6.0	12.1								
Setaria sp.	0.1	0.1	2.0	2.2								
Solanum carolinense	2.3	0.9	6.0	9.2								
Solidago juncea									11.3	4.1	18.4	33.8**
Solidago rugosa	19.3	4.6	14.0	37.9**								
Solidago sp.					0.3	0.2	2.3	2.8				
Trifolium sp.					0.7	0.2	2.3	3.2	0.4	3.9	5.3	9.6
Verbena urticifolia									0.4	0.2	2.6	3.2
Veronia fasciculata					2.8	1.0	11.6	15.4	4.4	0.5	5.3	10.2
Vicia sp.									0.2	0.4	5.3	5.9
Xanthium strumarium	0.5	0.6	6.0	7.0								

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[*] Importance value = relative cover + relative density + relative frequency.

[**] Major species (importance value ≥20).

Source: Texas Instruments Incorporated field data (1979-1980).

sweetgum, black locust, sassafras, black cherry, winged elm, redbud, and red maple. Japanese honeysuckle, blackberries, and grass species dominate the herbaceous and shrub strata. Other typical species are goldenrod, Queen Anne's lace, field bindweed, and trumpet vine.

3.3.3.5.3 Upland Hardwoods Forest

Data collected on the tree stratum in the Breckinridge site upland hardwoods are in Table 3.3-15. Seasonal data for the shrub and herbaceous strata are in Tables 3.3-16 and 3.3-17.

Upland hardwoods cover approximately 36% of the Breckinridge site. Most of these forests occupy hilly topography in the southeast portion of the site. Although sugar maple showed the highest importance value from sampling data, it does not dominate the cover type to that extent. At the base of slopes and along streams, sugar maple is typically the dominant overstory species. On the drier slopes and ridges, however, oaks and hickories are dominant and sugar maple is an understory species. Another factor in the prominence of sugar maple may be logging, which typically removes oaks and allows such understory species to become dominant. Common oaks and hickories in the area are white oak, northern red oak, chinkapin oak, shagbark hickory, and pignut hickory. The presence of a large number of intolerant species such as yellow poplar, black locust, and sassafras further indicates previous disturbance of the woodlands, probably from timber removal or agricultural clearing.

Table 3.3-15. Species Composition, Relative Values, and Importance Values for Tree Stratum, Upland Hardwoods Cover Type, Breckinridge Site, 1979

Species	Relative (%) Cover	Relative (%) Frequency	Relative (%) Density	Importance Value*
Acer saccharum	28.8	28.5	39.2	96.5**
Carpinus caroliniana	0.1	1.2	0.8	2.1
Carya glabra	1.9	1.2	0.8	3.9
Carya ovata	6.7	7.8	5.5	20.0**
Carya sp.	11.9	7.8	7.5	27.2**
Celtis occidentalis	0.1	2.7	1.7	4.5
Cercis canadensis	0.8	3.9	3.3	8.0
Cornus florida	0.4	3.9	2.5	6.8
Diospyros virginiana	1.5	3.9	2.5	7.9
Fraxinus americana	4.4	2.7	2.5	9.6
Juniperus virginiana	2.5	2.7	2.5	7.7
Juglans cinerea	0.1	1.2	0.8	2.1
Liriodendron tulipifera	6.0	5.1	5.8	16.9
Liquidambar styraciflua	0.2	1.2	0.8	2.2
Morus rubra	0.9	1.2	0.8	2.9
Quercus alba	11.8	2.7	4.2	18.7
Quercus muehlenbergii	2.6	2.7	2.5	7.8
Quercus rubra	12.3	3.9	2.5	18.7
Robinia pseudoacacia	2.1	6.6	5.0	13.7
Sassafras albidum	2.2	5.1	5.8	13.1
Ulmus rubra	2.6	3.9	3.3	9.8

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*Importance value = relative cover + relative frequency + relative density.

**Major species (importance value ≥20).

Source: Texas Instruments Incorporated field data (1979).

Table 3.3-16. Species Composition, Relative Values, and Importance Values for Shrub Stratum, Upland Hardwoods Cover Type, Breckinridge Site, 1979-1980

Taxa	October				May				July			
	Relative (%)			Importance Value*	Relative (%)			Importance Value*	Relative (%)			Importance Value*
	Cover	Density	Frequency		Cover	Density	Frequency		Cover	Density	Frequency	
Acer saccharum	42.1	22.0	23.0	87.1**	67.7	58.8	29.6	156.1**	5.3	13.0	14.4	32.7**
Aralia spinosa	5.3	3.4	3.9	17.9								
Asimina triloba	0.9	3.4	3.9	8.2								
Carpinus caroliniana					5.6	7.8	10.1	23.5**				
Carya ovata					1.9	2.0	5.0	8.9				
Carya sp.	10.5	6.8	7.6	24.9**								
Celtis occidentalis									2.6	4.3	7.2	14.1
Cercis canadensis	5.3	3.4	3.9	12.6								
Cornus florida	17.5	25.4	11.5	54.4**	1.9	2.0	5.0	8.9	21.1	30.4	28.4	79.9**
Fagus grandifolia	5.3	3.4	3.9	12.6	0.4	2.0	5.0	7.4				
Fraxinus americana					1.9	2.0	5.0	8.9				
Lindera benzoin	3.5	10.2	11.5	25.2**	1.9	3.9	5.0	10.8				
Liriodendron tulipifera	0.9	3.4	3.9	8.2								
Liquidambar styraciflua	0.9	3.4	3.9	8.2					2.6	4.3	7.2	14.1
Morus rubra	1.8	3.4	7.6	12.8								
Prunus serotina									2.6	4.3	7.2	14.1
Quercus alba					5.6	7.8	10.1	23.5**				
Quercus prinus					3.8	3.9	5.0	12.7				
Quercus rubra					1.9	2.0	5.0	8.9				
Sassafras albidum	5.3	10.2	11.5	27.0**								
Tilia americana					1.9	2.0	5.0	8.9				
Ulmus alata					3.8	3.9	5.0	12.7				
Ulmus rubra	0.9	1.7	3.9	6.5	1.9	2.0	5.0	8.9	60.5	34.8	28.4	123.7**
Viburnum acerifolium									5.3	8.7	7.2	21.2**

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[*] Importance value = relative cover + relative density + relative frequency.

[**] Major species (importance value ≥20).

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.3-17. Species Composition, Relative Values, and Importance Values for Herbaceous Stratum, Upland Hardwoods Cover Type, Breckinridge Site, 1979-1980

	October				May				July			
	Relative (%)			Importance Value*	Relative (%)			Importance Value*	Relative (%)			Importance Value*
Taxa	Cover	Density	Frequency		Cover	Density	Frequency		Cover	Density	Frequency	
Acer saccharum	6.2	2.3	8.5	17.0	4.5	3.1	4.3	11.9	9.5	6.4	6.6	22.5**
Asplenium platyneuron									0.6	0.9	1.4	2.9
Aster sp.	0.5	0.8	3.0	4.3								
Carex sp.	0.8	0.8	3.0	4.6	0.4	1.9	3.2	5.5	1.9	2.7	4.0	8.6
Carpinus caroliniana					0.9	0.6	1.1	2.6				
Carya cordiformis									8.8	3.6	4.0	16.4
Carya ovata					1.1	1.9	2.1	5.1				
Carya sp.	0.8	0.8	3.0	4.6					1.4	2.7	4.0	8.1
Celtis occidentalis									0.6	0.9	1.4	2.9
Cercis canadensis	4.7	1.5	3.0	9.2	2.7	3.1	3.2	9.0	0.6	0.9	1.4	2.9
Cornus florida	10.9	3.8	14.0	28.7**	4.5	2.5	3.2	10.2	10.1	8.2	6.6	24.9**
Dentaria heterophylla					3.1	4.9	5.3	13.3				
Dentaria laciniata					1.4	3.7	4.3	9.4				
Dioscorea quaternata									3.2	3.6	5.4	12.2
Dryopterus sp.	0.8	0.8	3.0	4.6								
Eupatorium rugosum	0.8	0.8	5.5	7.1								
Fagus grandifolia	0.8	0.8	3.0	4.6								
Fraxinus americana					10.1	3.1	3.2	16.4	0.6	0.9	1.4	2.9
Galium aparine					1.3	2.5	3.2	7.0	0.6	1.8	1.4	3.6
Galium circaezans	0.8	0.8	3.0	4.6	1.1	1.9	2.1	5.1				
Galium sp.									1.3	3.6	2.6	7.5
Geum canadense									0.6	0.9	1.4	2.9
Hepatica acutiloba									1.3	1.8	1.4	4.5
Juniperus virginiana					0.2	0.6	1.1	1.9				
Liquidambar styraciflua					1.8	2.5	2.1	6.4				
Liriodendron tulipifera									0.6	0.9	1.4	2.9
Lonicera japonica	62.0	76.3	11.4	149.7**	14.5	10.5	4.3	29.3**				
Morus rubra					0.2	0.6	1.1	1.9				
Osmorhiza claytonia	1.6	1.5	5.5	8.6								
Oxalis stricta									0.6	0.9	1.4	2.9
Parthenocissus quinquefolia	0.8	0.8	3.0	4.6	11.2	12.3	11.6	35.1**	7.1	13.6	10.7	31.4**
Phryma leptostachya					1.8	1.9	1.1	4.8				
Poaceae					7.6	6.2	7.5	21.3**				
Polygonatum biflorum					1.1	2.5	2.1	5.7	0.6	0.9	1.4	2.9
Prunus serotina					5.4	4.9	4.3	14.6	10.7	7.3	6.6	24.9**
Quercus alba	0.8	0.8	3.0	4.6	13.6	12.3	9.6	35.5**	0.6	0.9	1.4	2.9
Quercus prinus	1.6	1.5	5.5	8.6	10.9	1.2	1.1	3.2	1.9	2.7	4.0	8.6
Quercus rubra					0.2	0.6	1.1	1.9				
Ranunculus arbortivus					0.9	1.2	1.1	3.2				
Ranunculus sp.									1.3	2.7	1.4	5.4
Rhus radicans	1.6	1.5	5.5	8.6	1.8	1.2	2.1	5.1	22.1	10.9	8.0	41.0**
Rubus allegheniensis	0.8	0.8	3.0	4.6								
Sassafras albidum					0.5	1.9	3.2	5.6	2.5	4.5	4.0	13.5
Smilacena racemosa					1.8	2.5	2.1	6.4				
Smilacena sp.	0.8	0.8	3.0	4.6								
Smilax hispida	1.6	1.5	5.5	8.6								
Smilax sp.					0.9	0.6	1.1	2.6	2.6	4.5	5.4	12.5
Tradescantia subaspera					1.1	1.9	2.1	13.7	1.9	2.7	2.6	7.2
Ulmus alata					0.9	1.2	1.1	3.2				
Ulmus rubra	0.8	0.8	3.0	4.6					4.4	7.3	5.4	17.1
Viola papilionacea	0.8	0.8	3.0	4.6	2.4	4.3	5.3	12.0	0.6	0.9	1.4	2.9
Vitis vulpina									1.3	0.9	1.4	3.6

*Importance value = relative cover + relative density + relative frequency.

**Major species (importance value ≥20).

Source: Texas Instruments Incorporated field data (1979-1980).

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Important shrub species include sugar maple, dogwood, white oak, hickories, and slippery elm, all of which are characteristic understory species in an oak-hickory forest. Common herbaceous species are Virginia creeper, poison ivy, Japanese honeysuckle, and seedlings of sugar maple, dogwood, black cherry, and white oak. On the moister sites, along stream terraces, spicebush and American hornbeam are important understory species. Where disturbance has occurred, dense thickets of Japanese honesuckle, blackberry, smilax, and sassafras are common.

3.3.3.5.4 Lowland Hardwoods Forest

Data collected in October 1979 for the tree stratum of the lowland hardwoods are in Table 3.3-18. Seasonal data for the shrub and herbaceous strata are in Tables 3.3-19 and 3.3-20.

The most important overstory species in the Breckinridge site lowland hardwoods are boxelder, white ash, sycamore, sweetgum, yellow poplar, and American hornbeam. Important shrubs are boxelder, red maple, sugar maple, Ohio buckeye, pawpaw, bitternut hickory, other hickories, dogwood, beech, white ash, yellow poplar, sweetgum, and black cherry. Spicebush is most abundant.

Table 3.3-18. Species Composition, Relative Values, and Importance Values for Tree Stratum, Lowland Hardwoods Cover Type, Breckinridge Site, 1979

Species	Relative (%)			Importance Value*
	Cover	Frequency	Density	
Acer negundo	19.2	14.1	13.3	46.6**
Acer rubrum	6.9	4.2	4.2	16.6
Acer saccharum	5.5	4.3	6.7	16.5
Carpinus caroliniana	5.7	7.6	10.0	23.3**
Carya cordiformis	1.1	2.2	1.7	5.0
Carya glabra	2.7	1.0	0.8	4.5
Celtis occidentalis	0.7	3.3	3.3	7.3
Cercis canadensis	0.8	3.3	2.5	6.6
Cornus florida	0.5	2.2	1.7	4.4
Fagus grandifolia	0.5	2.2	1.7	4.4
Fraxinus americana	4.9	13.0	13.3	31.2**
Liriodendron tulipifera	20.0	5.5	4.2	29.7**
Liquidambar styraciflua	4.8	12.0	13.3	30.1**
Morus rubra	3.0	4.3	4.2	11.5
Platanus occidentalis	13.3	9.8	7.5	30.6**
Quercus muehlenbergii	2.7	1.0	0.8	4.5
Sassafras albidum	2.2	2.2	3.3	7.7
Ulmus rubra	5.6	6.5	7.5	19.6

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*Importance value = relative cover + relative frequency + relative density.

**Major species (importance value ≥20).

Source: Texas Instruments Incorporated field Data (1979).

Table 3.3-19. Species Composition, Relative Values, and Importance Values for Shrub Stratum, Lowland Hardwoods Cover Type, Breckinridge Site, 1979-1980

Taxa	October				May				July			
	Relative (%)			Importance Value*	Relative (%)			Importance Value*	Relative (%)			Importance Value*
	Cover	Density	Frequency		Cover	Density	Frequency		Cover	Density	Frequency	
Acer negundo	1.3	1.9	5.1	8.3	19.4	10.9	13.8	44.1**	1.5	2.2	4.4	8.1
Acer rubrum	20.3	5.6	9.9	35.8**								
Acer saccharum					19.4	13.0	18.3	50.7**	2.9	4.4	9.2	16.5
Aesculus glabra					13.9	4.3	2.2	20.4**				
Asimina triloba	1.3	1.9	5.1	8.3					8.8	11.0	13.7	33.5**
Carpinus caroliniana	7.6	3.7	5.1	16.4	2.8	4.3	4.5	11.6				
Carya cordiformis	10.1	7.4	9.9	27.4**								
Carya sp.					1.1	8.7	18.3	28.1**				
Celtis occidentalis	2.5	7.4	9.9	19.8	0.3	2.2	2.2	4.7				
Cornus florida					6.9	10.9	13.8	31.6**	2.9	16.5	9.2	28.6**
Fagus grandifolia	7.6	9.3	5.1	22.0**	15.2	6.5	9.3	31.0**	20.6	8.8	13.7	43.1**
Fraxinus americana	1.3	1.9	5.1	8.3	4.4	10.9	6.4	21.7**	5.9	8.8	9.2	23.9**
Hydrangea arborescens					1.4	2.2	2.2	5.8				
Lindera benzoin	25.3	31.5	20.0	76.8**					44.1	33.0	18.1	95.2**
Liriodendron tulipifera									4.4	8.8	9.2	22.4**
Liquidambar styraciflua	20.3	25.9	14.9	61.1**								
Platanus occidentalis	1.3	1.9	5.1	8.3								
Prunus serotina					13.9	23.9	4.5	42.3**	2.9	2.2	4.4	9.5
Sassafras albidum									2.9	2.2	4.4	9.5
Ulmus rubra	1.3	1.9	5.1	8.3	1.4	2.2	4.5	8.1	2.9	2.2	4.4	9.5

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*Importance value = relative cover + relative density + relative frequency.

**Major species (importance value ≥20).

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.3-20. Species Composition, Relative Values, and Importance Values for Herbaceous Stratum, Lowland Hardwoods Cover Type, Breckinridge Site, 1979-1980

	October				May				July			
	Relative (%)			Importance Value*	Relative (%)			Importance Value*	Relative (%)			Importance Value*
Taxa	Cover	Density	Frequency		Cover	Density	Frequency		Cover	Density	Frequency	
Acer negundo	1.1	0.9	2.9	4.9	1.2	1.3	1.6	4.1	0.1	0.6	1.3	2.0
Acer saccharum					0.5	0.6	1.6	2.7	0.9	0.6	3.8	5.3
Actaea alba					4.4	0.6	1.6	6.6				
Actinomeris alternifolia	3.2	1.1	4.5	8.8					9.1	1.1	1.3	11.5
Allium canadense					0.8	0.6	0.8	2.2				
Anemonella thalictroides					0.5	1.3	1.6	3.4				
Arisaema dracontium					0.8	1.3	1.6	3.7				
Arisaema triphyllum					0.9	1.9	2.4	5.2				
Asarum canadense					2.8	5.4	3.2	11.4	11.4	10.6	6.3	28.3**
Asimina triloba					0.5	0.6	1.6	2.7				
Aster lateriflorus	22.4	9.3	10.6	42.3**								
Aster sp.	17.8	2.4	1.6	21.8**								
Boehmeria cylindrica									5.9	3.4	3.8	13.1
Botrychium virginianum					0.5	0.6	1.6	2.7				
Campsis radicans	1.4	0.4	2.9	4.7								
Carex sp.	10.7	23.8	9.0	43.5**	0.5	0.6	1.6	2.7	0.5	0.6	1.3	2.4
Carya cordiformis	0.2	0.2	1.6	2.0								
Carya sp.					0.9	1.0	2.4	4.3				
Celtis occidentalis	0.2	0.2	1.6	2.0	0.4	0.6	0.8	1.8				
Cornus florida					0.9	1.3	2.4	4.6	1.0	2.2	3.8	7.0
Cryptotaenia canadensis									0.1	0.6	1.3	2.0
Cystopteris bulbifera					4.8	1.0	1.6	7.4				
Delphinium tricorne					0.4	0.6	0.8	1.8				
Dentaria laciniata					0.5	1.3	1.6	3.4				
Dicentra canadensis					0.4	0.6	0.8	1.8				
Equisetum hyemale					0.4	0.3	0.8	1.5				
Galium aparine					2.4	3.8	4.8	11.0	1.4	3.4	3.8	8.6
Galium circaezans					0.2	1.0	1.6	2.8	0.9	1.7	2.5	5.1
Geum canadense	0.2	0.2	1.6	2.0	9.7	4.8	2.4	16.9	0.5	0.6	1.3	2.4
Impatiens biflora	0.2	0.2	1.6	2.0								
Lindera benzoin	0.4	0.9	2.9	4.2	10.1	6.7	4.8	21.6**	2.7	3.9	6.3	12.9
Liquidambar styraciflua					0.1	0.3	0.8	1.2				
Liriodendron tulipifera					0.2	0.2	1.6	2.0	1.9	2.2	3.8	7.9
Lonicera japonica	3.6	2.6	2.9	9.1	18.5	13.8	6.4	38.7**	5.0	7.3	2.5	14.8
Osmorhiza claytonii	0.2	0.2	1.6	2.0								
Parthenocissus quinquefolia	0.4	0.4	2.9	3.7	2.7	4.2	6.4	13.3	28.8	24.6	17.6	71.0**
Phaseolus polystachios	4.3	1.8	6.1	12.2								
Phryma leptostachya					6.0	11.2	3.2	20.4**	2.7	6.1	7.6	16.4
Pilea pumila	22.4	45.6	13.5	81.5**					1.9	7.8	3.8	13.5
Poaceae					1.8	2.9	4.8	9.5				
Podophyllum peltatum					6.4	2.6	3.2	12.2				
Polygonatum biflorum					0.2	0.6	1.6	2.4				
Polygonum virginianum	2.8	3.5	6.1	12.4	1.6	4.2	1.6	7.4				
Polystichum acrostichoides	0.2	0.2	1.6	2.0	2.0	1.3	2.4	5.7	11.0	2.2	5.1	18.3
Prunus serotina					4.5	1.3	1.6	7.4	0.5	0.6	1.3	2.4
Quercus alba									0.5	0.6	1.3	2.4
Quercus rubra					1.2	1.0	1.6	3.8				
Ranunculus recurvatus					0.5	0.6	1.6	2.7				
Rhus radicans	2.5	3.1	10.6	16.2	3.7	4.5	4.8	13.0	8.2	7.3	8.9	24.4**
Sanguinaria canadensis					1.6	2.2	3.2	7.0	1.4	1.7	2.5	5.6
Sassafras albidum									0.9	1.7	2.5	5.1
Schizachne purpurascens	1.1	0.4	1.6	3.1								
Smilacina racemosa					0.5	1.0	1.6	3.1				
Smilax hispida	0.2	0.2	1.6	2.0								
Smilax sp.					0.4	0.3	0.8	1.5				
Solidago rugosa	1.4	0.7	4.5	6.6								
Trillium sessile					0.1	0.3	0.8	1.2				
Ulmus rubra	0.2	0.2	1.6	2.0	0.4	0.6	0.8	1.8				
Uniola latifolia	2.1	0.9	2.9	5.9								
Viola papilionacea	1.1	0.4	1.6	3.1	3.4	8.3	7.2	18.9	1.8	7.3	3.8	12.9
Vitis vulpina									0.9	1.7	2.5	5.1

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*Importance value = relative cover + relative density + relative frequency.

**Major species (importance value ≥20).

Source: Texas Instruments Incorporated field data (1979-1980).

Herbaceous cover, density, and seasonal occurance on the Breckinridge site are similar to the Hancock site. In late summer, large colonies of lopseed, clearweed, false nettle, and wingstem occur along the lower stream terraces. Other common herbaceous species include wild ginger, calico and other asters, sedges, spicebush, Japanese honeysuckle, Virginia creeper, and poison ivy.

3.3.3.5.5 Wetlands and Water Bodies

No wetlands are located within the boundaries of the Breckinridge site (see Figure 3.1-7), but the upper reaches of Town Creek, which is a wetland embayment, drain the entire site. Other nearby wetland embayments include Bull Creek and Sinking Creek.

Numerous small ponds located on the Breckinridge site have cattails and willows associated with them.

3.3.3.5.6 Breckinridge Transmission Corridor

The Breckinridge corridor has more gently rolling topography than the Hancock corridor and a greater percent of cropland and pasture cover. Upland hardwoods are limited in extent and are usually restricted to ridge-tops and steeper slopes. Lowland hardwoods are again restricted to stream habitats. Characteristic species of the various cover types are similar to the Hancock corridor.

3.3.3.6 Elizabethtown Transmission Corridor

Cropland and pasture is the most extensive cover type on the Elizabethtown corridor (see Figure 3.1-18). Corn and tobacco are the most widely planted crops, and pasture for livestock is prevalent. Species composition of fallow fields is typical of the project area as a whole.

Upland hardwood cover is patchy and limited. Most of the forests tracts are small and isolated from each other by farmland. The largest stands are near Cloverport and between Locust Hill and Custer in Breckinridge County. Most forests are restricted to hills and slopes not suitable for agriculture. Oak forests are typically on the rolling plateaus. The most abundant species are generally white oak, southern red oak, and black oak (Braun 1950). Associates include sugar maple, beech, yellow poplar, hickories, and white ash.

Lowland hardwood stands are also small and, as elsewhere in the study area, are restricted to stream courses. Silver maple and sycamore are common lowland species.

Old field cover types are produced from vegetation clearing and maintenance along the corridor as well as from agricultural abandonment. Eastern redcedar is common as are other species characteristic of this cover type throughout the study area.

A series of lakes and low lying depressions, collectively known as Hicks Lake, are located near Franklin Crossroads in Hardin County. This intermittently flooded area provides a wetland habitat for species such as buttonbush, smartweed, and willow.

The most notable vegetation stress along the corridor was due to herbicide use. Drift from aerial spraying damaged, and in some cases killed, tree, shrub, and ground vegetation bordering the corridor. Stress was most evident in the area from Tar Fork Creek in Cloverport to Hardin Mills Road.

3.3.4 Wildlife

The landforms and vegetation cover types described in the previous sections provide a variety of habitats for the regional wildlife. The northeastern corner of the Western Coal Field, containing the Hancock site, is especially important to wildlife of that part of Kentucky because it is virtually unmined. The Ohio River, its tributaries, ponds, and occasional wetlands provide habitats for these wildlife.

3.3.4.1 Wildlife of the Project Area

The project area supports 60 of Kentucky's 100 species of reptiles and amphibians (Table 3.3-21) and 242 of 275 bird species regularly reported from the Commonwealth (Table 3.3-22). Additionally 47 mammals are reported from the project area (Table 3.3-23), including 7 game species and several valuable furbearers. For interpretation of the tabular data, abundant wildlife are those species regularly observed in large numbers; common describes species that are regularly found in moderate numbers; uncommon species are frequently observed in small numbers; and scarce species are irregularly observed in small numbers. A notation of two categories of abundance indicates that abundance varies, depending on location.

3.3.4.2 Hancock Site

Most of the common and abundant wildlife of the project area, as well as some less common species, occur on the Hancock site (Table 3.3-24). These wildlife were observed during a 1979-1980 study of the Hancock and Breckinridge sites that included sampling of herpetofauna, birds, and mammals on each site. Sampling methodology is described in Section 5.0. Habitats surveyed for wildlife corresponded to the vegetation cover types discussed in the previous section.

3.3.4.2.1 Amphibians and Reptiles

Herpetofauna of the Hancock site comprise at least 20 species - 12 amphibians and 8 reptiles (Tables 3.3-25 and 3.3.-26). No Federally listed threatened and endangered species were observed, nor were any species on the Kentucky Nature Preserves Commission list seen. The lowland hardwoods, with its streams and floodplains, is the most important habitat for this group, which includes many woodlands species and is largely dependent on aquatic habitats for food and breeding. During spring and summer, standing water in the cropland and fallow areas provides additional breeding habitat for frogs and toads.

Consistent with the extent of habitat on the site, frogs and toads are the most abundant, as well as the most audible and visible herpetofauna on the site. The status of each species is similar to that statewide in suitable habitat: all are common to abundant except the pickerel frog, which is uncommon onsite as in the state. Consistent with the amount of onsite disturbance from agricultural activities, only the five-lined skink and eastern box turtle among

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Table 3.3-21. Distribution of Amphibians and Reptiles in the Project Area

Common Name	Scientific Name	Protective Listing	Abundance	Favored Habitat	State Distribution
SALAMANDERS					
Hellbender	Cryptobranchus alleganiensis		C	Streams	>Far W. Kentucky
Jefferson's Salamander	Ambystoma jeffersonianum		U	Moist woodlands	N. C. Kentucky
Small-mouthed Salamander	A. texanum		C	Streams and bayous	>Far E. Kentucky
Marbled Salamander	A. opacum		C	Wet and dry woodlands	Statewide
Spotted Salamander	A. maculatum		C	Woodlands	Statewide
Tiger Salamander	A. tigrinum		C	Variety	W. Kentucky
Red-spotted Newt	Notophthalmus viridescens		C	Moist woodlands	Statewide
Dusky Salamander	Desmognathus fuscus		C-A	Woodland streams	Statewide
Zigzag Salamander	Plethodon dorsalis		C-A	Rocky woodlands	W. Kentucky
Slimy Salamander	P. glutinosus		C-A	Woodlands	Statewide
Four-toed Salamander	Hemidactylium scutatum	KY	U	Woodlands	>Far W. Kentucky
Two-lined Salamander	Eurycea bislineata		C	Woodland streams	Statewide
Longtail Salamander	E. longicauda		C	Woodlands	Statewide
Cave Salamander	E. lucifuga		C	Limestone caves	>Far W. Kentucky
Mudpuppy	Necturus maculosus		C	Variety water bodies	Statewide
FROGS AND TOADS					
Eastern Spadefoot	Scaphiopus holbrooki		S	Variety	W. Kentucky
Bullfrog	Rana catesbeiana		A	Permanent water bodies	Statewide
Leopard Frog	Rana pipiens		A	Variety	Statewide
Green Frog	R. clamitans		A	Variety water bodies	Statewide
Pickerel Frog	R. palustris		U	Clear lakes, Streams, Ponds	Statewide
Wood Frog	R. sylvatica		U	Moist woodlands	E. Kentucky
Eastern Narrow-mouthed Toad	Gastrophryne carolinensis		U	Moist woodlands	C. Kentucky
American Toad	Bufo americanus		A	Variety	Statewide
Fowler's Toad	B. woodhousei		A	Variety	Statewide
Blanchard's Cricket Frog	Acris crepitans		C-A	Variety-aquatic	Statewide
Spring Peeper	Hyla crucifer		A	Moist woods and thickets	Statewide
Gray Treefrog	H. versicolor		A	Woodlands	Statewide
Striped Chorus Frog	Pseudacris triseriata		A	Wet meadows	W. Kentucky
TURTLES					
Snapping Turtle	Chelydra serpentina		C	Quiet water bodies	Statewide
Stinkpot	Sternotherus odoratus		A	Shallow muddy water bodies	W. Kentucky
Eastern Mud Turtle	Kinosternon subrubrum		U	Shallow water bodies	W. Kentucky
Eastern Box Turtle	Terrapene carolina		A	Woodlands	Statewide
Map turtle	Graptemys geographica		S	Large water bodies	C. Kentucky
Painted Turtle	Chrysemys picta		C-A	Shallow quiet water bodies	Statewide
Slider	C. scripta		C-A	Shallow quiet water bodies	>Far E. Kentucky
Smooth Softshell Turtle	Trionyx muticus		U	Clear, Sandy-bottom water body	Statewide
Spiny Softshell Turtle	T. spiniferus		U	Clear water bodies	Statewide
LIZARDS					
Fence Lizard	Sceloporus undulatus		A	Dry open woodlands	Statewide
Ground Skink	Scincella lateralis		C-A	Moist woodlands	>N. C. Kentucky
Five-lined Skink	Eumeces fasciatus		C	Variety-including old sawdust	Statewide
Broad-headed Skink	E. laticeps		U	Woodlands	Statewide
Six-lined Racerunner	Cnemidophorus sexlineatus		S	Sandy areas	W. Kentucky
SNAKES					
Worm Snake	Carphophis amoenus		A	Woodlands	Statewide
Ringneck Snake	Diadophis punctatus		C	Woodlands	Statewide
Eastern Hognose Snake	Heterodon platyrhinos		C	Woodland edge	Statewide
Rough Green Snake	Opheodrys aestivus		C	Woodlands	Statewide
Black Racer	Coluber constrictor		C	Woodlands-brush	Statewide
Rat Snake	Elaphe obsoleta		C	Variety	Statewide
Prairie Kingsnake	Lampropeltis calligaster	KY	S	Old fields-grasslands	W. Kentucky
Common Kingsnake	Lampropeltis getulus		C	Dry woodlands, Shrubs	>Far N.E. Kentucky
Milk Snake	L. triangulum		C	Variety	Statewide
Scarlet Snake	Cemophora coccinea	KY	C	Woodlands	Statewide
Southeastern Crowned Snake	Tantilla coronata	KY	U-C	Dry woodlands	W. Kentucky
Eastern Ribbon Snake	Thamnophis sauritus	KY	S	Adjacent water bodies	Statewide
Eastern Garter Snake	T. sirtalis		A	Adjacent water bodies	Statewide
Smooth Earth Snake	Virginia valeriae		S	Woodlands	Statewide
Brown Snake	Storeria dekayi		S	Variety	Statewide
Red-bellied Snake	S. occipitomaculata		U	Woodland	>N C. Kentucky
Queen Snake	Regina septemvittata		C-A	Rocky woodland stream	C. Kentucky
Northern Water Snake	Natrix sipedon		A	Water bodies	Statewide
Copperhead	Agkistrodon contortrix		C	Rocky woodland hills	Statewide
Timber Rattlesnake	Crotalus horridus		U	Rocky woodland ridges	Statewide

Legend: A = Abundant
C = Common
U = Uncommon
S = Scarce or unknown

Source: Barbour (1971).

(KY) Special Status – Kentucky Nature Preserve's Commission

Distribution
> – Occurs in all other areas except area mentioned
C – Central
N – Northern
E – Eastern
S – Southern
W – Western

Table 3.3-22. Distribution of Birds in the Project Area (Sheet 1 of 3)

Common Name	Scientific Name	Protective Listing	Abundance	Preferred Habitats	State Distribution	Status
Red-necked Grebe	*Podiceps grisegena*		S	Large water bodies	Predominantly C. and W. Kentucky	M,WR
Horned Grebe	*P. auritus*		S	Large water bodies	> E. Kentucky	M,WR
Eared Grebe	*P. caspicus*		S	Large water bodies	> E. Kentucky	M,WR
Pied-billed Grebe	*Podilymbus podiceps*		C	Shallow ponds	Statewide	M,R
Double-crested Cormorant	*Phalacrocorax auritus*	KY	C	Large water bodies	Statewide	M,R
Great Blue Heron	*Ardea herodias*	KY	C	Small water bodies	Statewide	M,R
Green Heron	*Butorides virescens*		C		Statewide	M,R
Little Blue Heron	*Florida caerulea*		C	Shallow marshes	Statewide	M,SR
Cattle Egret	*Bubulcus ibis*		S	Pastures	Statewide	SR
Great Egret	*Casmerodius albus*	KY	C	Shallow streams, Ponds	W. Kentucky	SR
Snowy Egret	*Egretta thula*		C	Shallow vegetated water bodies	Predominantly E. Kentucky	SR
Black-crowned Night Heron	*Nycticorax nycticorax*		S	Extensive marshes	W. Kentucky	SR
Yellow-crowned Night Heron	*Nyctanassa violacea*		S	Marshes, Sloughs, Wooded lakes	C. and W. Kentucky	SR
Least Bittern	*Ixobrychus exilis*		U	Shallow marshes and ponds	Predominantly W. Kentucky	SR
American Bittern	*Botaurus lentiginosus*	KY	U	Dense shallow marshes	Predominantly W. Kentucky	M,SR
Canada Goose	*Branta canadensis*		C	Large water bodies	Statewide	M,SR,WR
Snow Goose	*Chen caerulescens*		C-A	Large water bodies	Statewide	M
Mallard	*Anas platyrhynchos*		C-A	Variety water bodies	Statewide	M,SR,WR
Black Duck	*A. Rubripes*		U	Variety water bodies	Statewide	M,SR,WR
Gadwall	*A. strepera*		C-A	Variety water bodies	Statewide	M
Pintail	*A. acuta*		C	Variety water bodies	Statewide	M
Green-winged Teal	*A. crecca*		C	Variety water bodies	> Far E. Kentucky	M
Blue-winged Teal	*A. discors*		C	Variety water bodies	Statewide	M
American Wigeon	*A. penelope*		C-A	Variety water bodies	Statewide	M
Northern Shoveler	*A. clypeata*		C	Variety water bodies	Statewide	M
Wood Duck	*Aix sponsa*		C	Streams, Flooded bottomland	Predominantly C. and W. Kentucky	M,SR,WR
Redhead	*Aythya americana*	KY	U	Large water bodies	Predominantly C. and W. Kentucky	M,WR
Canvasback	*A. valisineria*	KY	U	Large water bodies	Predominantly C. and W. Kentucky	M,WR
Greater Scaup	*A. marila*		S	Large water bodies	Predominantly C. and W. Kentucky	M,WR
Lesser Scaup	*A. affinis*		C-A	Variety water bodies	Predominantly C. and W. Kentucky	M,WR
Common Goldeneye	*Bucephala clangula*		C	Variety water bodies	Predominantly C. and W. Kentucky	M,WR
Bufflehead	*B. albeola*		C	Large water bodies	Predominantly C. and W. Kentucky	M,WR
Oldsquaw	*Clangula hyemalis*		S	Large water bodies	Predominantly C. and W. Kentucky	M,WR
White-winged Scoter	*Melanitta deglandi*		S	Large water bodies	Predominantly C. and W. Kentucky	M,WR
Ruddy Duck	*Oxyura jamaicensis*		U-C	Large water bodies	Predominantly C. and W. Kentucky	M
Hooded Merganser	*Lophodytes cucullatus*		C	Large water bodies	Predominantly C. and W. Kentucky	M,WR
Common Merganser	*Mergus merganser*		C	Large water bodies	Predominantly C. and W. Kentucky	M,WR
Red-breasted Merganser	*M. serrator*		C	Variety water bodies	Predominantly C. and W. Kentucky	M
Turkey Vulture	*Cathartes aura*		C	Roosts on high cliffs	Statewide	R
Black Vulture	*Coragypes atratus*	KY	C	Roosts on high cliffs	Statewide	R
Sharp-shinned Hawk	*Accipiter striatus*	KY	S	Woodland, Woodland edge	Statewide	R
Cooper's Hawk	*A. cooperii*	KY	U-C	Woodland, Woodland edge	Statewide	R
Red-tailed Hawk	*Buteo jamaicensis*		C	Woodlands	Statewide	R
Red shouldered Hawk	*B. lineatus*	KY	C	Lowland forests	Statewide	R
Broad-winged Hawk	*B. platypterus*		U	Upland forests	Statewide	M,SR
Rough-legged Hawk	*B. lagopus*		S	Open habitats	Statewide	WR
Bald Eagle	*Haliaeetus leucocephalus*	US	U	Large water bodies	Statewide	M,SR,WR
Marsh Hawk	*Circus cyaneus*	KY	U-C	Open habitats, Marshes	Statewide	M,WR
Osprey	*Pandion haliaetus*	KY	U-C	Large water bodies	Statewide	M,SR
Merlin	*Falco femoralis*		S	Woodland openings, lake border	Statewide	M,WR
American Kestrel	*Falco sparverius*		C	Open habitat	Statewide	R
Bobwhite	*Colinus virginianus*		C	Open woodlands	Statewide	R
Turkey	*Meleagris gallopavo*	KY	U	Woodlands	Statewide	R
King Rail	*Rallus elegans*	KY	U	Marshes	Statewide	SR
Virginia Rail	*R. limicola*		S	Marshes	Predominantly C. and W. Kentucky	M
Sora	*Porzana carolina*		U	Marshes, Pastures	Predominantly C. and W. Kentucky	M
Common Gallinule	*Gallinala chloropus*	KY	S	Marshes with open water	Predominantly C. and W. Kentucky	M,SR
American Coot	*Fulica americana*		C-A	Large water bodies	Predominantly C. and W. Kentucky	M,SR
Semipalmated Plover	*Charadrius semipalmatus*		S-C	Flooded fields and shores	Predominantly C. and W. Kentucky	M
Killdeer	*C. vociferus*		C	Open habitats	Statewide	R
American Golden Plover	*Pluvialis dominica*		S	Upland fields, River flats	Statewide	M
Black-bellied Plover	*P. squatarola*		S	Upland fields, River flats	Statewide	M
Ruddy Turnstone	*Arenaria interpres*		S	Shoreline, Large water bodies	Statewide	M
American Woodcock	*Philohela minor*		U	Moist thickets, Woodland edge	Statewide	M,SR
Common Snipe	*Capella gallinago*		C	Mud flats, Flooded fields	Statewide	M
Upland Sandpiper	*Bartramia longicauda*	KY	S-U	Shores, Water bodies, Fields	Predominantly C. and W. Kentucky	M
Spotted Sandpiper	*Actitis macularia*		C	Shores, Water bodies, Fields	Predominantly C. and E. Kentucky	M,SR
Solitary Sandpiper	*Tringa solitaria*		C	Shores, Water bodies, Fields	Predominantly C. and W. Kentucky	M,SR

LEGEND: Protective Listing
US – Federal endangered or threatened species.
KY – Special status, Kentucky Nature Preserve Commission.

Abundance
A – Abundant
C – Common
U – Uncommon
S – Scarce or unknown

Distribution
> – Occurs in all other areas except area mentioned.
C – Central
N – Northern
E – Eastern
S – Southern
W – Western

Status
M – Migrant
R – Resident
SR – Summer resident
WR – Winter resident
WV – Winter visitor

Source: Barbour et al. (1973).

Table 3.3-22. Distribution of Birds in the Project Area (Sheet 2 of 3)

Common Name	Scientific Name	Protective Listing	Abundance	Preferred Habitats	State Distribution	Status
Willet	*Catoptrophorus semipalmatus*		S	Shores, Water Bodies, Fields	Statewide	M
Greater Yellowlegs	*Tringa melanoleuca*		C	Shores, Water Bodies, Fields	Statewide	M
Lesser Yellowlegs	*T. flavipes*		C	Shores, Water Bodies, Fields	Statewide	M
Red Knot	*Calidris canatusrufa*		S	Rocky shorelines	Statewide	M
Pectoral Sandpiper	*C. melanotos*		S	Mud flats, Rocky streambeds	Statewide	M
Least Sandpiper	*C. minutilla*		S-C	Mud flats, Rocky streambeds	Statewide	M
Dunlin	*C. alpina*		S	Mud flats, Rocky streambeds	Statewide	M
Short-billed Dowitcher	*Limnodromus scolopaceus*		S	Mud flats, Rocky streambeds	Statewide	M
Stilt Sandpiper	*Micropalama himantopus*		S	Mud flats, Rocky streambeds	Statewide	M
Semipalmated Sandpiper	*Calidris pusillus*		U	Sandy and rocky shorelines	Statewide	M
Sanderling	*C. alba*		S	Sandy and rocky shorelines	Statewide	M
Herring Gull	*Larus argentatus*		C	Large water bodies	Statewide	WR
Ring-billed Gull	*L. delawarensis*		C	Large water bodies	Statewide	WR
Franklin's Gull	*L. pipiycan*		U	Large water bodies	Statewide	M,WR
Bonaparte's Gull	*L. philadelphia*		S	Large water bodies	Statewide	M,WR
Forester's Tern	*Sterna forsteri*		U	Large water bodies	Statewide	M
Common Tern	*S. hirundo*		U	Large water bodies	Statewide	M
Least Tern	*S. albifrons*	KY	U	Large water bodies	Statewide	M,SR
Caspian Tern	*Hydroprogne caspia*		S	Large water bodies	Statewide	M
Black Tern	*Chlidonias niger*		U	Large water bodies	Statewide	M
Rock Dove	*Columba livia*		C	Croplands, Farmyards	Statewide	R
Mourning Dove	*Zenaida macroura*		C-A	Croplands and woodlands	Statewide	R
Yellow-billed Cuckoo	*Coccyzus americanus*			Woodlands	Statewide	R
Black-billed Cuckoo	*C. erythropthalmus*		U-C	Woodlands	Statewide	M,SR
Barn Owl	*Tyto alba*	KY	S-U	Open habitat, Barns	Statewide	R
Screech Owl	*Otus asio*		S-U	Woodland edge in croplands	Statewide	R
Great Horned Owl	*Bubo virginianus*		U	Woodlands	Statewide	R
Snowy Owl	*Nyctea scandiaca*		S	Open habitat	Statewide	WR
Barred Owl	*Strix varia*		C	Woodlands	Statewide	R
Long-eared Owl	*Asio otus*		S	Woodlands	Statewide	M,WR
Short-eared Owl	*A. flammeus*		U	Open habitat	Statewide	WR
Saw-whet Owl	*Aegolius acadicus*		U	Woodlands	Statewide	WR
Chuck-willis-widow	*Caprimulgus carolinensis*		U	Dry woodlands	Statewide	SR
Whip-poor-will	*C. vociferus*		U	Moist woodlands	Statewide	SR
Common Nighthawk	*Chordeiles minor*		U-C	Open habitat, Residential	Statewide	SR
Chimney Swift	*Chaetwra pelagica*		C	Cleared and residential	Statewide	SR
Ruby-throated Hummingbird	*Archilochus colubris*		C	Variety	Statewide	SR
Belted Kingfisher	*Megaceryle alcyon*		C	Large water bodies	Statewide	R
Common Flicker	*Colaptes auratus*		C	Woodlands	Statewide	R
Pileated Woodpecker	*Dryocopus pileatus*		C	Woodlands	Statewide	R
Red-bellied Woodpecker	*Centurus aurifrons*		U-C	Woodlands	Statewide	
Red-headed Woodpecker	*Melanerpes erythrocephalus*		C	Variety woodlands	W. Kentucky	R
Yellow-bellied Sapsucker	*Sphyrapicus varius*		C	Pine groves, Open woodlands	Statewide	M,WR
Hairy Woodpecker	*Dendrocopos villosus*		U	Large woodland tracts	Statewide	R
Downy Woodpecker	*D. pubescens*		C	Variety woodlands	Statewide	R
Eastern Kingbird	*Tyrannus tyrannus*		C	Open habitat	Statewide	SR
Great Crested Flycatcher	*Myiarchus crinitus*		C	Open woodlands	Statewide	SR
Eastern Phoebe	*Sayornis phoebe*		C	Variety woodlands	Statewide	SR
Yellow-bellied Flycatcher	*Empidonax flaviventris*		U	Deep woods and thickets	Statewide	M
Acadian Flycatcher	*E. virescens*		C	Riparian	Statewide	SR
Traill's Flycatcher	*E. traillii*		U	Riparian	Statewide	SR
Least Flycatcher	*E. minimus*		U-C	Open woodland	Statewide	M
Eastern Wood Peewee	*Contopus virens*		C	Woodlands	Statewide	SR
Olive-sided Flycatcher	*Nuttallornis borealis*		S	Woodland edges	Statewide	M
Horned Lark	*Eremophila alpestris*		C	Fallow field, Cropland	Statewide	R
Tree Swallow	*Iridoprocne bicolor*		U	Near water bodies	Statewide	M
Bank Swallow	*Riparia riparia*		U	Large streams	Statewide	M,SR
Rough-winged Swallow	*Stelgidopteryx ruficollis*		C	Open habitats	Statewide	SR
Barn Swallow	*Hirundo rustica*		C	Croplands, Barns	Statewide	SR
Cliff Swallow	*Petrochelidon pyrrhonota*		S	Near large water bodies	Statewide	SR
Purple Martin	*Progne subis*		C	Rural habitats	Statewide	SR
Blue Jay	*Cyanocitta cristata*		C	Woodlands	Statewide	R
Common Crow	*Corvus corax*		C	Open woodlands and croplands	Statewide	R
Carolina Chickadee	*Parus carolinensis*		C	Woodland edge	Statewide	R
Tufted Titmouse	*P. bicolor*		C	Dense woodland	Statewide	R
White-breasted Nuthatch	*Sitta carolinensis*		U-C	Woodlands	Statewide	R
Red-breasted Nuthatch	*S. canadensis*		U-C	Pine-oak woodlands	Statewide	M,WR
Brown Creeper	*Certhia familiaris*		C	Mature woodlands	Statewide	M,WR
House Wren	*Troglodytes brunneicollis*		U	Rural habitats	Statewide	M,SR
Winter Wren	*T. troglodytes*		C	Bottom woodland	Statewide	M,WR
Bewick's Wren	*Thryomanes bewickii*	KY	C	Farmlands, Rural	Statewide	R
Carolina Wren	*Thryothorus ludovicianus*		C	Woodland edge	Statewide	R
Long-billed Marsh Wren	*Telmatodytes palustris*		S	Wetlands	Statewide	M
Short-billed Marsh Wren	*Cistothorus platensis*		S-U	Wetlands	Statewide	M,SR
Mockingbird	*Mimus polyglottus*		C	Open shrub	Statewide	R
Gray Catbird	*Dumetella carolinensis*		C	Dense shrubs	Statewide	R
Brown Thrasher	*Toxostoma rufum*		C	Shrubs, Woodland edge	Statewide	R
American Robin	*Turdus migratorius*		C	Open woodlands	Statewide	R
Wood Thrush	*Hylocichla mustelina*		C	Woodlands	Statewide	SR
Hermit Thrush	*Catharus guttata*		U-C	Woodlands	Statewide	M,WR
Swainson's Thrush	*C. ustulata*		C	Woodlands	Statewide	M
Gray-cheeked Thrush	*C. minima*		C	Wooded hillsides	Statewide	M
Veery	*C. fuscescens*		U-C	Woodland edge	Statewide	M
Eastern Bluebird	*Sialia sialis*		C	Open woodlands	Statewide	R
Blue-gray Gnatcatcher	*Polioptila caerulea*		C	Open woodlands	Statewide	SR
Golden-crowned Kinglet	*Regulus satrapa*		C	Coniferous woodlands	Statewide	M,WR
Ruby-crowned Kinglet	*R. calendula*		C	Dense woodlands	Statewide	M
Water Pipit	*Anthus spinoletta*		U	Mud flats, Stream banks	Statewide	M
Cedar Waxwing	*Bombycilla cedrorum*		U	Open shrubs, Woodland edge	Statewide	R
Loggerhead Shrike	*Lanius excubitor*		U	Hedge rows in croplands	Statewide	R
Starling	*Sturnus vulgaris*		A	Cropland, Dead hooded timber	Statewide	R
White-eyed Vireo	*Vireo griseus*		C	Open woodlands, Shrubs	Statewide	SR
Bell's Vireo	*V. bellii*		R	Dense woodlands	Statewide	M
Yellow-throated Vireo	*V. flavifrons*		U-C	Mature woodlands	Statewide	SR
Solitary Vireo	*V. solitarius*		C	Dry woodlands and edges	Statewide	M,SR
Red-eyed Vireo	*V. olivaceus*		C	Woodlands	Statewide	SR
Philadelphia Vireo	*V. philadelphicus*		U-C	Bottom woodlands	Statewide	M
Warbling Vireo	*V. gilvus*		C	Open woodlands	Statewide	SR

Table 3.3-22. Distribution of Birds in the Project Area (Sheet 3 of 3)

Common Name	Scientific Name	Protective Listing	Abundance	Preferred Habitats	State Distribution	Status
Black-and-white Warbler	*Mniotilta varia*		C	Dense woodlands	Statewide	M,SR
Prothonotary Warbler	*Protonotaria citrea*		C	Wooded swamps	Statewide	SR
Swainson's Warbler	*Limnothlypis swainsonii*		R	Wooded swamps	Statewide	SR
Worm-eating Warbler	*Helmitheros vermivorus*		U-C	Wooded hillsides	Statewide	SR
Tennessee Warbler	*Vermivora pregrina*		C-A	Woodlands	Statewide	M
Orange-crowned Warbler	*V. celata*		R	Second-growth woodlands	Statewide	M
Nashville Warbler	*V. ruficapilla*		C	Second-growth woodlands	Statewide	M
Northern Parula	*Parula americana*		C	Wooded swamps	Statewide	SR
Yellow Warbler	*Dendroica petechia*		C	Riparian	Statewide	M,SR
Magnolia Warbler	*D. magnolia*		C	Woodlands	Statewide	M
Cape May Warbler	*D. tigrina*		U	Woodlands	Statewide	M
Black-throated Blue Warbler	*D. carrulescens*		U	Woodland edge	Statewide	M
Yellow-rumped Warbler	*D. coronata*		U-C	Variety	Statewide	M,WR
Black-throated Green Warbler	*D. virens*		C	Wooded hillsides	Statewide	M,SR
Cerulean Warbler	*D. cerulea*		C	Mature woodlands	Statewide	SR
Blackburnian Warbler	*D. fusca*		U-C	Mature woodlands	Statewide	M
Yellow-throated Warbler	*D. dominica*			Woodlands	Statewide	SR
Chestnut-sided Warbler	*D. pensylvanica*		U-C	Open woodlands	Statewide	M
Bay-breasted Warbler	*D. castanea*		U	Woodlands	Statewide	M
Blackpoll Warbler	*D. striata*		U	Woodlands	Statewide	M
Pine Warbler	*D. pinus*		U	Pine woodlands	Statewide	M,SR
Prairie Warbler	*D. discolor*		S	Variety habitats	Statewide	SR
Palm Warbler	*D. palmarum*		U	Open woodlands, Shrubs	Statewide	M,WR
Ovenbird	*Seiurus aurocapillus*		U	Woodlands	Statewide	M,SR
Northern Waterthrush	*S. noveboracensis*		C	Riparian	Statewide	M
Louisiana Waterthrush	*S. motacilla*		C	Riparian	Statewide	SR
Kentucky Warbler	*Oporornis formosus*		C	Shady moist woodlands	Statewide	SR
Connecticut Warbler	*O. agilis*		U	Open woodlands	Statewide	M
Mourning Warbler	*O. philadelphia*		S-U	Shrubs	Statewide	M
Common Yellowthroat	*Geothlypis trichas*		C	Shrubs Woodland edge	Statewide	SR
Yellow-breasted Chat	*Icteria virens*		C	Shrubs, Woodland edge	Statewide	SR
Hooded Warbler	*Wilsonia citrina*		U-C	Mature woodland	Statewide	M,SR
Wilson Warbler	*W. pusilla*		U-C	Hedge rows, Open woodlands	Statewide	M
Canada Warbler	*W. canadensis*		C	Open woodlands	Statewide	M
American Redstart	*Setophaga ruticilla*		U	Bottom woodland	Statewide	SR
House Sparrow	*Passer domesticus*		C-A	Residential	Statewide	R
Bobolink	*Dolichonyx oryzivorus*		U	Pastures	Statewide	M
Eastern Meadowlark	*Sturnella megna*		C	Croplands, Pastures, Fields	Statewide	R
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*		U	Sloughs and marshes	Statewide	M
Red winged Blackbird	*Agelaius phoeniceus*		C	Croplands, Marshes	Statewide	R
Orchard Oriole	*Icterus spurius*		C	Farmyards, Roadside parks	Statewide	SR
Northern Oriole	*I. galbula*		U	Open meadows with large trees	Statewide	SR,M
Rusty Blackbird	*Euphagus carolinus*		U	Croplands, Marshes	Statewide	M,WR
Brewer's Blackbird	*E. cyanocephalus*		S	Croplands, Marshes	Statewide	M,WR
Common Grackle	*Quiscalus quiscula*		C-A	Croplands, Parks	Statewide	R
Brown-headed Cowbird	*Molothrus ater*		C	Pastures, Croplands	Statewide	R
Scarlet Tanager	*Piranga aeneus*		S	Woodlands	Statewide	SR
Summer Tanager	*P. rubra*		C	Open woodlands, Parks	Statewide	SR
Cardinal	*Cardinalis cardinalis*		C	Woodlands, Shrubs	Statewide	R
Rose-breasted Grosbeak	*Pheucticus ludovicianus*		U-C	Mature woodlands	Statewide	M
Blue Grospeak	*Guiraca caerulea*		U	Riparian, Shrubs	Statewide	M,SR
Indigo Bunting	*Passerina cyanea*		C	Shrubs, Woodland edge	Statewide	SR
Dickcissel	*Spiza americana*		C	Fallow fields	Statewide	SR
Evening Grosbeak	*Hesporiphona vespertina*		C	Woodlands	Statewide	WR
Purple Finch	*Carpodacus purpureus*		U-C	Fallow fields, Hedgerows	Statewide	M,WR
Pine Siskin	*Spinus pinus*		U	Open woodlands	Statewide	WR
American Goldfinch	*S. tristis*		C	Fallow fields, Woodland edge	Statewide	R
Rufous-sided Towhee	*Pipilo erythropthalmus*		C	Second-growth woodland	Statewide	R
Savannah Sparrow	*Passerculus sandwichensis*		C	Fallow fields	Statewide	M
Grasshopper Sparrow	*Ammodramus savannarum*		C	Fallow fields	Statewide	SR
Vesper Sparrow	*Pooecetes gramineus*	KY	U-C	Fallow fields	Statewide	M,SR
Henslow's Sparrow	*Ammospiza henslowii*	KY	U	Fallow fields	Statewide	M,SR
Lark Sparrow	*Chondestes grammacus*		U	Fallow fields	Statewide	SR
Bachman's Sparrow	*Aimophila aestivalis*	KY	U-C	Fallow fields	Statewide	SR
Dark-eyed Junco	*Junco hyemalis*		C-A	Variety open	Statewide	M,WR
Tree Sparrow	*Spizella arborea*		C	Fallow fields	Statewide	WR
Chipping Sparrow	*S. passerina*		C	Shrubs	Statewide	SR
Field Sparrow	*S. pusilla*		C	Shrubs	Statewide	R
White-crowned Sparrow	*Zonotrichia leucophrys*		C	Shrubs	Statewide	WR
White-throated Sparrow	*Z. albicollis*		C	Shrubs, Riparian	Statewide	M,WR
Fox Sparrow	*Passerella iliaca*		C-U	Fallow fields	Statewide	M,WR
Lincoln's Sparrow	*Melospiza lincolnii*		U-C	Fallow fields, Woodland edge	Statewide	M
Swamp Sparrow	*M. georgiana*		C	Wet fallow fields	Statewide	M,WR
Song Sparrow	*M. melodia*		C	Shrubs, Fallow fields	Statewide	R
Lapland Longspur	*Calcarius lapponicus*		U	Bare ground	Statewide	WR
Snow Bunting	*Plectrophenax nivalis*		U	Variety open	Statewide	WV

Reproduced from best available copy.

Table 3.3-23. Distribution of Mammals in the Project Area

Common Name	Scientific Name	Protective Listing	Abundance	Favored Habitat	State Distribution
Oppossum	Didelphis marsupialis		A	Variety	Statewide
Masked Shrew	Sorex cinereus	KY	U	Variety	E. Kentucky
Southeastern Shrew	Sorex longirostris	KY	U	Moist areas	Statewide
Short tailed Shrew	Blarina brevicauda		A	Variety	Statewide
Least Shrew	Cryptotis parva		C	Grasslands	Statewide
Eastern Mole	Scalopus aquaticus		A	Variety	Statewide
Little Brown Bat	Myotis lucifugus		C	Woodlands	Statewide
Gray Myotis	M. grisescens	US	S	Woodlands	C. Kentucky
Keen's Myotis	M. keeni	KY	S	Woodlands	Statewide
Indiana Bat	M. sodalis	US	S	Woodlands	Statewide
Small-footed Myotis	M. subulatus	KY	U	Woodlands	C. Kentucky
Silverharried Bat	Lasionycteris noctivagans	KY	U	Woodlands	Statewide
Eastern Pipistrelle	Pipistrellus subflavus		C	Woodlands	Statewide
Big Brown Bat	Eptesicus fuscus		A	Woodlands	Statewide
Red Bat	Lasiurus borealis		A	Woodlands	Statewide
Hoary Bat	L. cinereus	KY	U	Woodlands	Statewide
Evening Bat	Nycticeius humeralis	KY	U	Woodlands	S. West Kentucky
Eastern Big-eared Bat	Plecotus rafinesquei	KY	U	Woodlands	Statewide
Eastern Cottontail Rabbit	Sylvilagus floridanus		A	Variety	Statewide
Swamp Rabbit	S. aquaticus	KY	S	Woodland bottoms	W. Kentucky
Eastern Chipmunk	Tamias striatus		C	Woodlands	Statewide
Woodchuck	Marmota monax		U	Woodlands (open)	Statewide
Gray Squirrel	Sciurus carolinensis		C	Woodlands bottoms	Statewide
Fox Squirrel	S. niger		C	Woodland ridge	Statewide
Southern Flying Squirrel	Glaucomys volans		C	Woodlands	Statewide
Beaver	Castor canadensis		C	Wooded water bodies	Statewide
Rice Rat	Oryzomys palustris		S	Wet meadows, Marshes	W. Kentucky
Eastern Harvest Mouse	Reithrodontomys humulis		U	Grassy fields	Statewide
Deer Mouse	Peromyscus maniculatus		C	Variety	> E. Kentucky
White footed Mouse	P. leucopus		A	Woodlands and brush	Statewide
Golden Mouse	P. nuttalli		U	Woodlands	Statewide
Meadow Vole	Microtus pennsylvanicus		A	Grassy fields	E. Kentucky
Prarie Vole	M. ochrogaster		A	Grassy fields	Statewide
Pine Vole	Pitymys pinetorum		U-C	Woodlands	Statewide
Muskrat	Ondatra zibethica		C	Marshes	Statewide
Southern Bog Lemming	Synaptomys cooperi		C	Wet meadows	> W. Kentucky
Norway Rat	Rattus norvegicus		C	Buildings	Statewide
House Mouse	Mus musculas		C	Buildings	Statewide
Meadow Jumping Mouse	Zapus hudsonius	KY	U	Grassy fields	> E. Kentucky
Red Fox	Vulpes fulva		C	Open woodlands	Statewide
Gray Fox	Urocyon cinereoargenteus		C	Open woodlands	Statewide
Raccoon	Procyon lotor		A	Woodlands	Statewide
Long-tailed Weasel	Mustela frenata		C	Variety near water	Statewide
Mink	M. vison		C	Streams in woodlands	Statewide
Striped Skunk	Mephitis mephitis		C	Brushy areas	Statewide
Bobcat	Lynx rufus	KY	S	Woodlands	Statewide
White-tailed Deer	Odocoileus virginianus		C	Woodlands	Statewide

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US Federal endangered or threatened species.

KY Special Status, Kentucky Nature Preserve Commission.

A - Abundant.

C - Common.

U - Uncommon.

S - Unknown or scarce.

Source: Barbour and Davis (1979).

Nomenclature for mammals: follows Burt and Grossenheider (1976).

Distribution
> - Occurs in all other areas except area mentioned
C - Central
N - Northern
E - Eastern
S - Southern
W - Western

Table 3.3-24. Checklist of Wildlife Species, Hancock Site, 1979-1980

Amphibians and Reptiles

Dusky Salamander
Long-tailed Salamander
Red-spotted Newt
American Toad
Fowler's Toad
Blanchards Cricket Frog
Spring Peeper
Gray Treefrog
Green Frog
Leopard Frog
Bullfrog
Pickerel Frog
Eastern Box Turtle
Painted Turtle
Fence Lizard
Five-lined Skink
Broad-headed Skink
Black Racer
Eastern Garter Snake
Rat Snake

Birds

Great Blue Heron
Great Egret
Green Heron
Black Vulture
Red-tailed Hawk
Marsh Hawk
American Kestrel
Bobwhite
American Coot
Killdeer
Common Snipe
Spotted Sandpiper
Least Sandpiper
Rock Dove
Mourning Dove
Yellow-billed Cuckoo
Black-billed Cuckoo
Chimney Swift
Ruby-throated Hummingbird
Common Flicker
Pileated Woodpecker
Red-bellied Woodpecker
Red-headed Woodpecker
Hairy Woodpecker
Downy Woodpecker
Eastern Kingbird
Great-crested Flycatcher
Eastern Phoebe
Acadian Flycatcher
Barn Swallow
Tree Swallow
Purple Martin
Blue Jay
Common Crow
Carolina Chickadee
Tufted Titmouse
White-brested Nuthatch
House Wren
Carolina Wren
Mockingbird
Gray Catbird
Brown Thrasher
American Robin
Wood Thrush
Hermit Thrush

Birds (Contd)

Eastern Bluebird
Blue-gray Gnatcatcher
Cedar Waxwing
Starling
White-eyed Vireo
Solitary Vireo
Red-eyed Vireo
Warbling Vireo
Black-and-white Warbler
Prothonotary Warbler
Worm-eating Warbler
Tennessee Warbler
Northern Parula
Black-throated Blue Warbler
Yellow-rumped Warbler
Pine Warbler
Louisiana Waterthrush
Kentucky Warbler
Chestnut-sided Warbler
Blackburnian Warbler
Common Yellowthroat
Yellow-brested Chat
Canada Warbler
American Redstart
House Sparrow
Eastern Meadowlark
Red-winged Blackbird
Orchard Oriole
Brewer's Blackbird
Common Grackle
Brown-headed Cowbird
Scarlet Tanager
Cardinal
Indigo Bunting
American Goldfinch
Rufous-sided Towhee
Savannah Sparrow
Field Sparrow
Song Sparrow
Tree Sparrow
Chipping Sparrow
White-crowned Sparrow
White-throated Sparrow

Mammals

Opossum
Short-tailed Shrew
Eastern Mole
Evening Bat
Eastern Cottontail Rabbit
Eastern Chipmunk
Woodchuck
Gray Squirrel
Fox Squirrel
White-footed Mouse
Meadow Vole
Pine Vole
Muskrat
House Mouse
Red Fox
Gray Fox
Raccoon
Long-tailed Weasel
Mink
Striped Skunk
White-tailed Deer

Source: Texas Instruments Incorporated field data (1979-1980).

References: American Ornithologists Union (1957) and periodic updates.
Conant (1958).
Robbins et al. (1966).
Burt and Grossenheider (1976).

Table 3.3-25. Number of Amphibians and Reptiles Observed per Hour, Hancock Site, 1979-1980

Species	Cropland			Fallow Field			Lowland Hardwoods			Upland Hardwoods		
	Oct	May	Jul	Oct	May	Jul	Oct	May	Jul	Oct	May	Jul
Dusky Salamander									2*			
Red-spotted Newt										3*		
American Toad		Ch*	1		2			2	2		2	3
Fowler's Toad		Ch*						1	1			
Blanchards Cricket Frog		Ch*	Ch*		Ch*							
Spring Peeper							5	Ch				
Gray Treefrog							3	Ch	Ch		Ch	
Green Frog		3*		11*		1	10*	3*	6*	4*	10*	5*
Leopard Frog		14*	12*	15*	3*	5*	3*					
Bullfrog				7*			5*		4*		2*	
Pickerel Frog							1*		1*			
Eastern Box Turtle			1		1	2	1	3	5			5
Painted Turtle					3*							
Five-lined Skink							2	1	1			4
Broad-headed Skink											1	
Black Racer												1
Eastern Garter Snake			1		1*							
Rat Snake					1							
Total Species	0	5	5	3	7	3	8	7	9	2	5	5

*Associated with streams, ponds, or standing water.

Ch - Chorus (10+ individuals).

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.3-26. Estimated Abundance of Amphibians and Reptiles Observed on the Hancock Site, 1979-1980

Species	Cropland	Fallow Field	Lowland Hardwoods	Upland Hardwoods
Dusky Salamander			U*	
Longtail Salamander				U
Red-spotted Newt				U*
American Toad	C*	C	C	C
Fowler's Toad	C*	C	C	C
Blanchards Cricket Frog	C*	C*		
Spring Peeper			C*	
Gray Treefrog			C	U
Green Frog	U*	C*	A*	A*
Leopard Frog	A*	A*	C*	U*
Bullfrog	U*	C*	C*	U*
Pickerel Frog			U*	
Eastern Box Turtle	U	U	A	A
Painted Turtle		U*		
Fence Lizard			U	
Five-lined Skink			C	C
Broad-headed Skink				U
Black Racer				U
Eastern Garter Snake	U	U		
Rat Snake		U		
Total Species	8	10	12	12

*Associated with streams, ponds or other water bodies.

A - Abundant C - Common U - Uncommon

Source: Texas Instruments Incorporated field data (1979-1980).

the other herpetofauna observed appear to be as common there as in the Commonwealth. Status of the uncommon broad-headed skink, which is the most arboreal of Kentucky's skinks, is similar.

3.3.4.2.2 Birds

Eighty-eight bird species were observed on the Hancock site (Tables 3.3-27, 3.3-28, 3.3-29). The fewest (32) were observed during October and the most (65) were present in May during spring migration; summer populations consisted of at least 51 species. No Federally listed species were seen, but four species observed on or near the site are on the Kentucky Nature Preserves Commission Animal Element List: The great blue heron, great egret, black vulture, and marsh hawk.

The upland and lowland hardwoods appear to be equally important for bird life on the Hancock site. The open habitats provide food for some species but, having limited stratification, provide few resting or breeding sites. The hardwoods contain not only branches, tree cavities, and other suitable roosting/nesting sites but a greater variety of nuts, insects, and fleshy fruits, among other food items.

Important year-round residents of the site's woodlands include six woodpeckers: the common flicker and the red-bellied, red-headed, hairy, pileated, and downy. The red-bellied, which is more common in western than in eastern Kentucky, appears the most abundant of the site's woodpeckers, and the hairy, as in the state, appears least abundant. The white-breasted nuthatch, which feeds on bark-inhabiting insects while the woodpeckers feed on woodborers, also is an important year-round resident in the hardwoods.

Other predatory residents on the site include the black vulture, red-tailed hawk, and American kestrel. The marsh hawk, which is a migrant and winter resident in the area, may be an important seasonal predator on the site. Open habitats are favored by the marsh hawk and American kestrel, which frequetly roost on posts and utility lines. The black vulture and red-tailed hawk hunt in open areas but roost and nest in hardwoods. Observations indicate that Jeffry Cliff contains important loafing and roosting habitat for the vulture.

The mourning dove is the most abundant upland game bird on the site and in the Commonwealth, followed by the bobwhite. The bobwhite, although a resident like the dove, is primarily a southern species whose populations regularly are diminished in northern portions of its range by severe winters (Ellis et al. 1969). The Kentucky bobwhite populations presently are reduced because of the winters of 1977-1978 and 1978-1979 (Durell, personal communication 1980). With waterfowl apparently uncommon in the vicinity of the site, the mourning dove and bobwhite reprsent the only sizeable game bird populations there. Open habitats near brush or woodlands are important to both species.

Wading and shore birds, like waterfowl, are uncommon on the site. Most waders and shore birds are migrants or summer residents in the area, although the great blue and green herons are potential residents in suitable habitats. The green heron was observed in the lowland hardwoods during spring, summer, and fall and probably resides on the site, although no nests were found. A single great egret was observed near a stock pond in October.

Table 3.3-27. Number and Frequency of Birds Observed along 25-Kilometer Road Route, Hancock Site, 1979-1980

Species	October		May		July	
	Number	Frequency	Number	Frequency	Number	Frequency
Black Vulture	4	0.04	3	0.04	2	0.04
Red-tailed Hawk	1	0.04				
American Kestrel	2	0.08			2	0.08
Bobwhite			3	0.08	7	0.12
Killdeer			1	0.04		
Rock Dove	4	0.08	2	0.04		
Mourning Dove	4	0.08	12	0.24	35	0.48
Yellow-billed Cuckoo	1	0.04	3	0.12	6	0.20
Black-billed Cuckoo			1	0.04	2	0.08
Chimney Swift					1	0.04
Ruby-throated Hummingbird					2	0.04
Common Flicker	6	0.16	3	0.12	1	0.04
Pileated Woodpecker			2	0.08	1	0.04
Red-bellied Woodpecker	5	0.16	8	0.32	2	0.08
Red-headed Woodpecker			5	0.20		
Hairy Woodpecker					2	0.08
Downy Woodpecker	4	0.16	3	0.12	4	0.16
Eastern Kingbird			2	0.08	3	0.08
Great-crested Flycatcher					2	0.08
Eastern Phoebe			2	0.04	1	0.04
Acadian Flycatcher					1	0.04
Barn Swallow					18	0.16
Tree Swallow			14	0.16	2	0.04
Purple Martin					2	0.04
Blue Jay	23	0.60	27	0.48	20	0.44
Common Crow	6	0.12	9	0.24	16	0.24
Carolina Chickadee	4	0.08			2	0.04
Tufted Titmouse	3	0.08			2	0.04
White-breasted Nuthatch			2	0.08	2	0.04
House Wren			1	0.04		
Carolina Wren			2	0.04	1	0.04
Mockingbird			2	0.04	5	0.12
Gray Catbird	6	0.16	14	0.44	2	0.08
Brown Thrasher			2	0.08	1	0.04
American Robin	4	0.08	13	0.28		
Wood Thrush			8	0.28	2	0.08
Hermit Thrush			2	0.08		
Eastern Bluebird			2	0.04		
Blue-gray Gnatcatcher			1	0.04		
Starling	6	0.08	7	0.16	1	0.04
White-eyed Vireo			2	0.08		
Red-eyed Vireo			4	0.16		
Warbling Vireo			3	0.08		
Worm-eating Warbler			4	0.08		
Tennessee Warbler			15	0.24		
Yellow-rumped Warbler			4	0.08		
Kentucky Warbler	1	0.04	1	0.04	3	0.08
Common Yellowthroat			7	0.20		
Yellow-breasted Chat			1	0.04	1	0.04
Canada Warbler	1	0.04				
House Sparrow			14	0.12	8	0.12
Brewers Blackbird			2	0.04		
Eastern Meadowlark	20	0.20	7	0.20	12	0.24
Red-winged Blackbird	16	0.08	28	0.48	6	0.08
Orchard Oriole			1	0.04		
Common Grackle	2	0.04	8	0.16	10	0.20
Brown-headed Cowbird					17	0.12
Scarlet Tanager			5	0.16		
Cardinal	9	0.24	26	0.60	17	0.52
Indigo Bunting			18	0.44	18	0.44
American Goldfinch			7	0.08	2	0.04
Rufous-sided Towhee			9	0.32		
Savannah Sparrow			1	0.04		
Field Sparrow	8	0.16	7	0.16		
Song Sparrow	1	0.04	3	0.12	3	0.04
Tree Sparrow					4	0.08
White-throated Sparrow			8	0.08		
Chipping Sparrow					2	0.04
Total Species	24		53		44	

Source: Texas Instruments Incorporated field data (1979-1980).

$$\text{Frequency} = \frac{\text{number of stops observed}}{\text{number of stops}}$$

Table 3.3-28. Density* of Birds Observed along Transects, Hancock Site, 1979-1980

Species	Cropland			Fallow Field			Lowland Hardwoods			Upland Hardwoods		
	Oct	May	Jul	Oct	May	Jul	Oct	May	Jul	Oct	May	Jul
Marsh Hawk	10											
American Kestrel				10								
Bobwhite						20			20			
Common Snipe					10							
Killdeer					20							
Mourning Dove	70	20	50		10				40			
Yellow-billed Cuckoo									20		40	20
Black-billed Cuckoo											20	20
Common Flicker							160	20	20			
Pileated Woodpecker							20	20		20	20	
Red-bellied Woodpecker							60	40		80	20	20
Red-headed Woodpecker								20	20		40	
Hairy Woodpecker										20		
Downy Woodpecker								20	20	20		20
Eastern Phoebe								40		40		40
Barn Swallow						20						
Tree Swallow					30							
Blue Jay							60	20	40	80	100	20
Common Crow			40	10				40		80		
Carolina Chickadee										100		80
Tufted Titmouse							20		20			40
White-breasted Nuthatch								20		120	40	
Carolina Wren								20				20
Mockingbird					10	10						
Gray Catbird								40			60	
Brown Thrasher								20				
American Robin		10			30		20					20
Wood Thrush							20	20	20		80	60
Hermit Thrush												20
Cedar Waxwing							80	60				
White-eyed Vireo											80	
Solitary Vireo										20	60	
Red-eyed Vireo											60	60
Prothonotary Warbler												20
Black-and-White Warbler								40				
Worm-eating Warbler								80			40	
Tennessee Warbler								120			120	
Black-throated Blue Warbler											80	
Yellow-rumped Warbler								80			80	
Pine Warbler								20		40		
American Redstart										40	40	
Louisiana Waterthrush											20	
Kentucky Warbler									60			
Common Yellowthroat								40	20			
Yellow-breasted Chat							20		40			
Chestnutsided Warbler											80	
Blackburnian Warbler											60	
Northern Parula												40
Eastern Meadowlark	80		40	30	40	20						
Red-winged Blackbird	150	30			40	10						
Common Grackle		20			60		60					
Scarlet Tanager								20			40	
Cardinal	10			10	10		40	80	40	20	40	60
Indigo Bunting								80	20		40	
Rufous-sided Towhee								60			40	
Field Sparrow					10							
Song Sparrow	10			20	20		20					
Tree Sparrow			10									
White-crowned Sparrow					20							
White-throated Sparrow								120				
Total Density	330	80	140	80	310	80	580	1140	400	680	1300	560
Total Species	6	4	4	5	13	5	12	25	14	13	24	16

*Density per 40 hectares.

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.3-29. Seasonal Maximum Counts of Aquatic Birds, Hancock Site, 1979-1980

Species	October	December	May	July
Great Blue Heron	1		1	
Great Egret	1			
Green Heron	3		2	3
Killdeer	1			
Least Sandpiper			1	
Spotted Sandpiper			2	
American Coot			2	
Dabbling Ducks		15		
Total Species	4	1	5	1

Source: Texas Instruments Incorporated field data (1979-1980).

The most abundant perching bird residents on the site, in addition to the white-breasted nuthatch, are the American robin, blue jay, common crow, Carolina chickadee, eastern meadowlark, cardinal and red-winged blackbird. The hardwoods are most important to the cardinal, robin, and jay, while the cropland and fallow field are favored by the meadowlark and blackbird.

Perching birds commonly utilizing the site during spring migration include the Tennessee, yellow-rumped, chestnut-sided, blackburnian and black-throated blue warblers. Warblers arriving in spring and maintaining summer residence include the American redstart, common yellowthroat, yellow-breasted chat, pine warbler, and Kentucky warbler. Among the more common summer residents on the site are the indigo bunting and wood thrush. The hardwoods support all of these species.

3.3.4.2.3 Mammals

Twenty-one species of mammals were observed on the Hancock site (Tables 3.3-30 and 3.3-31), including the evening bat, which is on the Kentucky Nature Preserves Commission Animal Element List. The various habitats on the site are generally utilized by a greater proportion of mammal species than bird species. Croplands and fallow fields are inhabited by several small mammals and are used by larger mammals seasonally for food and year-round for migratory routes between hardwoods. Still, the hardwoods are the most intensely used

Table 3.3-30. Number of Small Mammals per 100 Trap-Nights, Hancock Site, 1979-1980

	Cropland			Fallow Field			Lowland Hardwoods			Upland Hardwoods		
Species	Oct	May	Jul	Oct	May	Jul	Oct	May	Jul	Oct	May	Jul
Short-tailed Shrew				1				1		1		1
White-footed Mouse	1						1	6	3	5	1	6
Eastern Chipmunk									1	1	1	2
Pine Vole												1
Meadow Vole	4			5		1						
House Mouse	1											
Long-tailed Weasel									1			
Total per 100 Trap-nights	6	0	0	6	0	1	1	7	5	7	2	10
Total Species	3	0	0	2	0	1	1	2	3	3	2	4

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.3-31. Estimated Abundance of Mammals Observed on the Hancock Site, 1979-1980

Species	Cropland	Fallow Field	Lowland Hardwoods	Upland Hardwoods
Opossum	C	C	C (6.7)	C
Short-tailed Shrew		U	U	U
Eastern Mole	U	C	C	U
Evening Bat				C
Eastern Cottontail Rabbit	U	C	C	U
Eastern Chipmunk			C (20.0)	A (100.0)
Woodchuck	C	C (3.3)	C (6.7)	C (13.3)
Gray Squirrel	U		C (26.7)	A (60.0)
Fox Squirrel	U		U	C (20.0)
White-footed Mouse	U		C	C
Meadow Vole	U	U		
Pine Vole				U
Muskrat	C*	C*		
House Mouse	U			
Red Fox	U	U	U	U
Gray Fox			U	U
Raccoon	U*	U*	A	C
Long-tailed Weasel	U		C	
Mink	U*	U*	U*	
Striped Skunk		C		
White-tailed Deer	C	C	C	C (6.7)
Total Species	15	12	15	15

*Occur primarily along streams.
A - Abundant C - Common U - Uncommon.
(#) - Number per 40-hectare-transect counts.

Source: Texas Instruments Incorporated field data (1979-1980).

habitats and their relatively small extent limits population sizes of some of Kentucky's more abundant mammals. The site's three streams are important for all of the larger mammals and especially the furbearers.

The most abundant small mammals on the site are the white-footed mouse and the eastern chipmunk, both woodlands residents. The pine vole, meadow vole, and short-tailed shrew appear uncommon on the site, although the shrew and meadow vole are reported common statewide in suitable habitat. The pine vole is uncommon west of the Bluegrass Region.

The most abundant of the mid-sized mammals are the opossum and woodchuck, both of which utilize open as well as wooded areas on the site. The most abundant of the more restricted mid-sized species are the gray squirrel, muskrat, and raccoon. Each of these species is common to abundant throughout the state as well. The mink, long-tailed weasel, and eastern cottontail rabbit appear somewhat less common on the site than reported statewide. None of the large mammals except the white-tailed deer is common on the site.

Although some are not as abundant as reported elsewhere in the Commonwealth, all of the Kentucky game mammals observed on the site are common in at least one habitat type. These include the woodchuck, gray and fox squirrels, white-tailed deer, and eastern cottontail rabbit. Important furbearers on the site include the muskrat, red and gray foxes, and raccoon. As indicated, the foxes appear uncommon, while the muskrat and raccoon are common. Fur sales in Kentucky during the 1978-1979 trapping season amounted to nearly $3 million (Kentucky Department of Fish and Wildlife Resources). Raccoon furs were 37% of this value; gray and red fox furs were 27% and 18%; and muskrat furs were 10%.

Habitat for the evening bat is the Jeffry Cliff area. Four to eight of these primarily woodland inhabitants were observed during each sampling period on the site, indicating the species probably is a resident.

3.3.4.3 Hancock Transmission Corridor

The part of the Hancock transmission corridor just south of the Hancock site includes a ridge formation similar to Jeffry Cliff, which may provide habitat for the evening bat. This ridge and the comparatively large extent of forested habitat indicate the corridor probably supports all of the species found on the site and woodland species in proportionately greater numbers.

3.3.4.4 Breckinridge Site

Wildlife of the Breckinridge site is similar to that of the Hancock site. Herpetofauna and avifauna observed during the 1979-1980 survey of the site varied somewhat from those observed on the Hancock site, but the numbers of species were equivalent (Table 3.3-32). Fewer mammal species were observed, however, probably reflecting absence of mature hardwoods habitat similar to that on the Hancock site.

Table 3.3-32. Checklist of Wildlife Species, Breckinridge Site, 1979-1980

Amphibians and Reptiles

Red-spotted Newt
American Toad
Fowler's Toad
Blanchards Cricket Frog
Spring Peeper
Gray Treefrog
Green Frog
Leopard Frog
Bullfrog
Pickerel Frog
Snapping Turtle
Stinkpot
Eastern Box Turtle
Painted Turtle
Fence Lizard
Five-lined Skink
Broad-headed Skink
Black Racer
Eastern Garter Snake
Rat Snake

Birds

Great Blue Heron
Great Egret
Green Heron
Mallard
Wood Duck
Black Vulture
Broad-winged Hawk
Merlin
American Kestrel
Bobwhite
American Coot
Killdeer
Spotted Sandpiper
Rock Dove
Mourning Dove
Yellow-billed Cuckoo
Black-billed Cuckoo
Screech Owl
Chimney Swift
Ruby-throated Hummingbird
Common Flicker
Pileated Woodpecker
Red-bellied Woodpecker
Red-headed Woodpecker
Hairy Woodpecker
Downy Woodpecker
Eastern Kingbird
Great-crested Flycatcher
Least Flycatcher
Eastern Phoebe
Acadian Flycatcher
Barn Swallow
Tree Swallow
Purple Martin
Blue Jay
Common Crow
Carolina Chickadee
Tufted Titmouse
White-brested Nuthatch
House Wren
Carolina Wren

Birds (Contd)

Mockingbird
Gray Catbird
Brown Thrasher
American Robin
Wood Thrush
Hermit Thrush
Eastern Bluebird
Blue-gray Gnatcatcher
Logerhead Shrike
Starling
White-eyed Vireo
Solitary Vireo
Red-eyed Vireo
Warbling Vireo
Black-and-white Warbler
Prothonotary Warbler
Worm-eating Warbler
Tennessee Warbler
Prairie Warbler
Hooded Warbler
Yellow-rumped Warbler
Pine Warbler
Northern Waterthrush
Kentucky Warbler
Common Yellowthroat
Yellow-brested Chat
Canada Warbler
House Sparrow
Eastern Meadowlark
Red-winged Blackbird
Orchard Oriole
Brewer's Blackbird
Common Grackle
Brown-headed Cowbird
Scarlet Tanager
Cardinal
Indigo Bunting
American Goldfinch
Rufous-sided Towhee
Savannah Sparrow
Field Sparrow
Song Sparrow
Tree Sparrow
Chipping Sparrow
White-crowned Sparrow
White-throated Sparrow

Mammals

Opossum
Short-tailed Shrew
Eastern Mole
Eastern Cottontail Rabbit
Eastern Chipmunk
Woodchuck
Gray Squirrel
Fox Squirrel
White-footed Mouse
Red Fox
Gray Fox
Raccoon
Mink
Striped Skunk
White-tailed Deer

Source: Texas Instruments Incorporated field data (1979-1980).

References: American Ornithologists Union (1957) and periodic updates.
Conant (1958).
Robbins et al. (1966).
Burt and Grossenheider (1976).

3.3.4.4.1 Amphibians and Reptiles

Twenty species of herpetofauna were observed on the Breckinridge site. Neither Federally listed nor Kentucky Nature Preserves Commission listed species were seen. Lowland hardwoods and fallow areas, especially those near Town Creek, are the most important herpetofauna habitats on the Breckinridge site (Table 3.3-33 and 3.3-34), as they are on the Hancock site. Frog and toad species were the same as those observed on the Hancock site and abundance was generally equivalent. The most obvious difference in frog and toad distribution on the two sites is the limited use of upland hardwoods on the Breckinridge site by toads and arboreal frogs.

No salamanders were observed on the Breckinridge site, nor was the broad-headed skink. Three herpetofauna species observed there but not on the Hancock site were the stinkpot, snapping turtle, and northern water snake. All appear uncommon on the site, although the latter two species are common to abundant statewide in suitable habitat. The stinkpot, a musk turtle primarily occurring in comparatively low elevations, is abundant in western Kentucky and less common eastward.

3.3.4.4.2 Birds

Eighty-seven bird species were observed on the Breckinridge site (Tables 3.3-35, 3.3-36, and 3.3-37). The number of species observed each sampling period was consistent with observations on the Hancock site: The fewest (38) were observed in October, the most (64) in May, and summer populations consisted of at least 50 species. No Federally listed species were observed on or near the site, but three species on the Kentucky Nature Preserves Commission Animal Element List were observed: the black vulture, great blue heron, and great egret. The two waders are associated with the Town Creek embayment near the site. The black vulture was observed flying over the site's hardwoods, but important roost areas were not observed. The lowland and upland hardwoods contain considerably greater numbers of individuals and species of birds than do the open habitats.

The six woodpeckers observed on the Hancock site reside on the Breckinridge site as well, and the red-bellied again appears most abundant. Abundant species among the other bird groups also are similar: the American kestrel is the most abundant bird of prey; the morning dove is the predominant upland game bird; the most abundant spring migrants are the Tennessee and yellow-rumped warblers; common summer residents include the indigo bunting and wood thrush; and the blue jay, cardinal, Carolina chicadee, and red-winged blackbird are the most abundant year-round passerines. In general, warblers and hawk-like species are more diverse and abundant on the Hancock site, primarily because of Jeffry Cliff, while aquatic species are more diverse and numerous on the Breckinridge site because of Town Creek embayment.

3.3.4.4.3 Mammals

Fifteen species of mammals - none listed - were observed on the Breckinridge site (Tables 3.3-38 and 3.3-39). Most of the mammals obeserved on the Hancock site but not observed on the Breckinridge site were small mammals. Among the larger mammals, the muskrat was not observed on the Breckinridge site, although it likely occurs there.

Table 3.3-33. Number of Amphibians and Reptiles Observed per Hour, Breckinridge Site, 1979-1980

	Cropland			Fallow Field			Lowland Hardwoods			Upland Hardwoods		
Species	Oct	May	Jul	Oct	May	Jul	Oct	May	Jul	Oct	May	Jul
American Toad		1			2		1	3	4		2	1
Fowler's Toad					2			1				
Blanchards Cricket Frog		Ch*	Ch*		Ch*	Ch*						
Spring Peeper								Ch*				1*
Gray Treefrog							2	Ch	Ch	1		Ch
Green Frog			3*	5*	7*	20*	3*	2*	12*	2*	3*	11*
Leopard Frog			5*	13*	8*	11*	12*	4*	10*			
Bullfrog				9*	4*	2*	10*	1*	8*			
Pickerel Frog							1*		1*			
Snapping Turtle					1*	1*						
Stinkpot		2*				2*						
Eastern Box Turtle								4	4		2	5
Painted Turtle				9*	13*	15*						
Five-lined Skink												2
Northern Water Snake					1*			1*				
Black Racer									1			
Eastern Garter Snake						1*						
Rat Snake		1*										
Total Species	0	4	3	4	9	8	6	9	8	2	3	6

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* Associated with streams, ponds, or standing water.

Ch — Chorus (10 + individuals).

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.3-34. Estimated Abundance of Amphibians and Reptiles Observed on the Breckinridge Site, 1979-1980

Species	Cropland	Fallow Field	Lowland Hardwoods	Upland Hardwoods
Red-spotted Newt			U	
American Toad	U	U	C	C
Fowler's Toad		U	U	
Blanchards Cricket Frog	C*	C*		
Spring Peeper			C*	U*
Gray Treefrog			C*	C
Green Frog	C*	A*	A*	A*
Leopard Frog	C*	A*	A*	
Bullfrog		A*	A*	
Pickerel Frog			U*	
Snapping Turtle		U*		
Stinkpot	U*	U*		
Eastern Box Turtle			C	C
Painted Turtle		A*		
Fence Lizard				U
Five-line Skink				U
Northern Water Snake		U*	U*	
Black Racer			U	
Eastern Garter Snake	U	U*		
Rat Snake	U			
Total Species	7	11	12	7

A - Abundant C - Common U - Uncommon

* - Associated with streams, ponds, or other water bodies.

Ch - Chorus (10 + individuals)

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.3-35. Number and Frequency of Birds Observed along a 25-Kilometer Road Route, Breckinridge Site, 1979-1980

Species	October		May		July	
	Number	Frequency	Number	Frequency	Number	Frequency
Green Heron					1	0.04
Wood Duck	2	0.04				
Black Vulture	1	0.04				
Merlin			1	0.04		
Broach-winged Hawk					1	0.04
American Kestrel	1	0.04			2	0.08
Bobwhite			4	0.08	6	0.16
Killdeer			2	0.08	1	0.04
Rock Dove	3	0.08			11	0.16
Mourning Dove	10	0.08	12	0.24	36	0.60
Yellow-billed Cuckoo			3	0.12	7	0.24
Black-billed Cuckoo	1	0.04			2	0.08
Screech Owl			1	0.04		
Chimney Swift			4	0.08	6	0.08
Ruby-throated Hummingbird					1	0.04
Common Flicker	6	0.24	1	0.04	4	0.16
Pileated Woodpecker	1	0.04			2	0.08
Red-bellied Woodpecker	2	0.08	10	0.32	3	0.12
Red-headed Woodpecker					5	0.16
Hairy Woodpecker	1	0.04				
Downy Woodpecker	7	0.20			7	0.24
Eastern Kingbird			4	0.08	3	0.08
Great-crested Flycatcher					2	0.08
Eastern Phoebe			3	0.08	2	0.08
Acadian Flycatcher			1	0.04		
Barn Swallow			6	0.12	14	0.28
Tree Swallow			1	0.04	7	0.12
Purple Martin					2	0.04
Blue Jay	22	0.52	13	0.32	17	0.48
Common Crow	16	0.24	16	0.28	8	0.16
Carolina Chickadee	4	0.08	5	0.08	8	0.24
Tufted Titmouse	2	0.04			6	0.16
White-breasted Nuthatch	3	0.08			6	0.18
Carolina Wren					2	0.04
Mockingbird	3	0.08	5	0.16	4	0.16
Gray Catbird			7	0.16	8	0.28
Brown Thrasher			5	0.16	2	0.08
American Robin			21	0.40	21	0.40
Wood Thrush	1	0.04	7	0.24	6	0.16
Hermit Thrush					1	0.04
Veery			2	0.04		
Blue-gray Gnatcatcher			3	0.08		
Loggerhead Shrike			1	0.04		
Starling	59	0.24	16	0.20	6	0.20
White-eyed Vireo			1	0.04	1	0.04
Red-eyed Vireo					5	0.16
Warbling Vireo			3	0.12		
Worm-eating Warbler			1	0.04		
Tennessee Warbler			2	0.08		
Yellow-rumped Warbler	12	0.04	2	0.04		
Pine Warbler	1	0.04	1	0.04		
Kentucky Warbler					3	0.08
Common Yellowthroat			5	0.16	3	0.08
Yellow-breasted Chat			5	0.20		
House Sparrow			7	0.08	28	0.40
Brewers Blackbird			4	0.08		
Eastern Meadowlark	34	0.16	10	0.20	16	0.24
Red-winged Blackbird	16	0.12	42	0.44	6	0.16
Northern Oriole			2	0.08		
Common Grackle			85	0.40	35	0.40
Brown-headed Cowbird	38	0.08	3	0.08	6	0.08
Scarlet Tanager			5	0.12		
Cardinal	26	0.48	33	0.60	21	0.48
Indigo Bunting			21	0.44	16	0.40
American Goldfinch	3	0.04			2	0.04
Rufous-sided Towhee			4	0.12		
Chipping Sparrow			3	0.08		
Field Sparrow	11	0.12	7	0.12	4	0.12
Song Sparrow	3	0.12	10	0.16	2	0.04
Tree Sparrow			3	0.08		
White-throated Sparrow	8	0.08				
Dark-eyed Junco	4	0.04				
Total Species	30		50		49	

Source: Texas Instruments Incorporated field data (1979-1980).

$$\text{Frequency} = \frac{\text{number of stops observed}}{\text{number of stops}}$$

Table 3.3-36. Density* of Birds Observed along Transects, Breckinridge Site, 1979-1980

	Cropland			Fallow Field			Lowland Hardwoods			Upland Hardwoods		
Species	Oct	May	Jul	Oct	May	Jul	Oct	May	Jul	Oct	May	Jul
Wood Duck							40					
Bobwhite									20			
Rock Dove	60											
Mourning Dove	10	20	40		10				20			40
Yellow-billed Cuckoo								20	20		40	
Black-billed Cuckoo								20			40	
Ruby-throated Hummingbird								10				
Common Flicker							40			20	20	20
Pileated Woodpecker											20	20
Red-bellied Woodpecker							80	40		20	60	
Red-headed Woodpecker									20			40
Downy Woodpecker							60		20	20	20	20
Eastern Phoebe							40				40	20
Least Flycatcher							20				20	
Barn Swallow		20				20						
Blue Jay							100	60	40	100	40	140
Common Crow			20	20							40	40
Carolina Chickadee								40	20	80	40	60
Tufted Titmouse												40
White-breasted Nuthatch							20			60		80
Carolina Wren								20			40	
Mockingbird					10							
Gray Catbird								20			40	
American Robin		20		20			120			20		20
Wood Thrush									20		60	20
Hermit Thrush											20	
Ruby-crowned Kinglet							20					
Blue-gray Gnatcatcher								40				
Starling								40				
Red-eyed Vireo								40			60	
Black-and-White Warbler											40	
Worm-eating Warbler								40			60	
Tennessee Warbler								120			60	
Yellow-rumped Warbler							100	20			40	
Prairie Warbler								20				
Northern Waterthrush								20				
Kentucky Warbler									20			
Common Yellowthroat								40	20		40	
Yellow-breasted Chat								40			40	20
Hooded Warbler											20	
Canada Warbler								20			40	
Eastern Meadowlark	20		10		20							
Red-winged Blackbird		80			10	10						
Orchard Oriole					20							
Common Grackle		50					80					
Cardinal					10		80	60	60		120	40
Indigo Bunting								80	40			
Rufous-sided Towhee					20			40			40	
Field Sparrow					30							
Song Sparrow	40				20	10						
Tree Sparrow				30								
Chipping Sparrow		10		20								
Total Density	130	200	70	90	160	40	800	850	320	320	1040	620
Total Species	4	6	3	4	9	3	13	22	12	7	26	15

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*Density per 40 hectares.

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.3-37. Seasonal Maximum Counts of Aquatic Birds, Breckinridge Site, 1979-1980

Species	October	December	May	July
Great Blue Heron	1	7		1
Great Egret				1
Green Heron	3			2
Mallard	1		2	
Wood Duck	2		17*	1
Killdeer				2
Spotted Sandpiper			2	
American Coot			1	
Total Species	4	1	4	5

---

*Hen plus 16 ducklings.

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.3-38. Number of Small Mammals per 100 Trap-Nights, Breckinridge Site, 1979-1980

Species	Cropland			Fallow Field			Lowland Hardwoods			Upland Hardwoods		
	Oct	May	Jul	Oct	May	Jul	Oct	May	Jul	Oct	May	Jul
Short-tailed Shrew										1		1
White-footed Mouse			1			1	7	6	4	4	1	3
Eastern Chipmunk										2	6	4
Total per 100 Trap-nights	0	0	1	0	0	1	7	6	4	7	7	8
Total Species	0	0	1	0	0	1	1	1	1	3	2	3

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.3-39. Estimated Abundance of Mammals Observed on the Breckinridge Site, 1979-1980

Species	Cropland	Fallow Field	Lowland Hardwoods	Upland Hardwoods
Opossum	C	C (3.3)	C	C
Short-tailed Shrew				U
Eastern Mole	U	C	C	
Eastern Cottontail Rabbit	C (6.7)	C (6.7)	U	
Eastern Chipmunk			A (13.3)	A (66.7)
Woodchuck	U	U (3.3)	C (6.7)	C (6.7)
Gray Squirrel	U		A (13.3)	A (66.7)
Fox Squirrel	U		U	C (13.3)
White-footed Mouse	U	U	A	C
Red Fox	U	U	U	U
Gray Fox			U	
Raccoon	U	U	C (6.7)	C
Mink				
Striped Skunk	U (3.3)	U		
White-tailed Deer	C	C	C-A (6.7)	C-A
Total Species	11	9	12	10

A = Abundant C = Common U = Uncommon
(#) Number per 40 hectares (transect counts)
* = occur primarily along streams

Source: Texas Instruments Incorporated field data (1979-1980).

In general, mammals are not as widespread on the Breckinridge site and a few species are not as abundant. Distributions of the opossum, gray squirrel, fox squirrel, white-footed mouse, eastern cottontail rabbit, and striped skunk are like those on the Hancock site. The short-tailed shrew, eastern mole, woodchuck, gray fox, raccoon, and mink appear to have more limited distributions on the Breckinridge site. The white-tailed deer, however, appears somewhat more abundant on the Breckinridge site and equally widespread.

3.3.4.7 Breckinridge Transmission Corridor

Like the Hancock corridor, the location of greatest relief in the Breckinridge corridor is just south of U.S. Highway 60. This area, which is associated with Little Beech Fork of Clover Creek (see Figure 3.3-5), appears to contain the most important woodland and riparian wildlife habitat of the corridor. Open habitat species prevail in other locations of the corridor, in association with the extensive agricultural areas.

3.3.4.8 Elizabethtown Transmission Corridor

Ridge habitat comparable to the Jeffrey Cliff area and the areas south of each site is absent along the Elizabethtown corridor. Some of the riparian habitats associated with streams and water bodies crossed by the corridor appear to be the most important wildlife locations along the entire corridor. These are most extensive in the Tar Fork and Clover Creek crossings south of Cloverport between the Hancock corridor and the Breckinridge corridor. The [illegible]

Table 3.3-37. Seasonal Maximum Counts of Aquatic Birds, Breckinridge Site, 1979-1980

Species	October	December	May	July
Great Blue Heron	1	7		1
Great Egret				1
Green Heron	3			2
Mallard	1		2	
Wood Duck	2		17*	1
Killdeer				2
Spotted Sandpiper			2	
American Coot			1	
Total Species	4	1	4	5

---

*Hen plus 16 ducklings.

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.3-38. Number of Small Mammals per 100 Trap-Nights, Breckinridge Site, 1979-1980

	Cropland			Fallow Field			Lowland Hardwoods			Upland Hardwoods		
Species	Oct	May	Jul	Oct	May	Jul	Oct	May	Jul	Oct	May	Jul
Short-tailed Shrew										1		1
White-footed Mouse			1			1	7	6	4	4	1	3
Eastern Chipmunk										2	6	4
Total per 100 Trap-nights	0	0	1	0	0	1	7	6	4	7	7	8
Total Species	0	0	1	0	0	1	1	1	1	3	2	3

Source: Texas Instruments Incorporated field data (1979-1980).

embayments associated with these streams are the most significant waterfowl and aquatic bird habitats on the corridor. The Rough River riparian habitats and the wetlands comprising the Hicks Lake complex are other important wildlife locations.

No Federal threatened or endangered species are reported from the vicinity of the corridor. There also are no records of Kentucky Nature Preserves Commission listed species, but presence of the great blue heron and great egret in the embayments mentioned above seems likely.

3.4 WATER

3.4.1 Project Area

As shown in the discussion on land use of the project area and vicinity (Subsection 3.1.2.1.3; Figure 3.1-5), important surface water resources and aquatic habitats are the Ohio River, its tributaries, and the embayments created at the mouth of larger tributaries. The river and streams, along with domestic, municipal, and industrial well systems, provide most of the project area's water requirements. Reservoirs, including Freeman Lake near Elizabethtown, provide some of the surface water requirements along the Elizabethtown corridor.

3.4.1.1 Ohio River

The Ohio River flows southwesterly 981 miles from the confluence of the Allegheny and Monongahela rivers at Pittsburgh to the Mississippi River at Cairo, Illinois. There are 21 major tributaries along this length, and the entire watershed comprises 203,980 square miles (Table 3.4-1). The Ohio River Basin, which excludes the Tennessee River watershed, consists of 163,070 square miles within 11 states (Figure 3.4-1). The Hancock and Breckinridge sites - river miles (RM) 715 and 705, respectively - are in the Lower Ohio Main Stem subregion of the Basin, which consists of 12,570 square miles within the last 435 miles of the river (Figure 3.4-1; Table 3.4-2). This watershed includes drainages of several minor tributaries but excludes areas drained by the Green, Wabash, and Cumberland rivers. Tributaries to the Lower Ohio Main Stem within a 5-mile radius of the Hancock and Breckinridge sites are shown in Table 3.4-3.

A series of locks and dams built on the Ohio River by the COE facilitates navigation in the Ohio Basin. The Hancock and Breckinridge sites lie between the McAlpine Lock and Dam at RM 606.8 and Cannelton Lock and Dam at RM 720.7. The COE presently maintains a normal elevation of 382.3 feet msl in the Cannelton Pool, which assures a 9-foot deep navigation channel throughout this reach of the river during low-flow periods. The pool level is controlled by adjusting the gates at the Cannelton Dam and during flood conditions, the gates are raised.

3.4.1.1.1 Water Availability

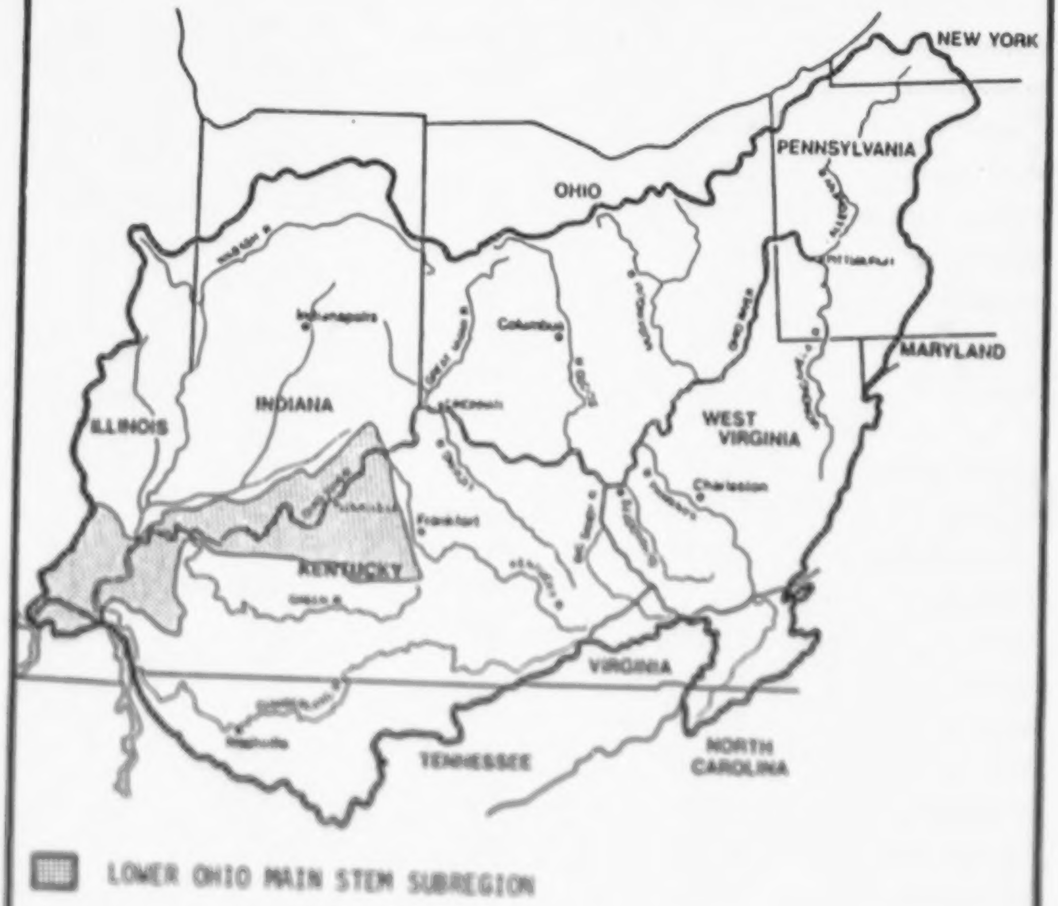
Within the Ohio River Basin, average annual precipitation varies from 36 inches in east central Illinois to 50 inches in south central Kentucky. Maximum yearly precipitation during 30 years of record has varied from 47 inches in northeastern Ohio to 72 inches in Paducah, Kentucky, at the confluence of the Ohio and Tennessee rivers. The minimum yearly precipitation for the same period varied from 20 inches at Parkersburg, West Virginia on the Ohio River to 36 inches in south central Kentucky. A one-year monitoring period at the Hancock site recorded 42 inches, which closely approximates the project area average of 45 inches.

The amount of average annual runoff from annual precipitation over the Ohio Basin is approximately 40%. During 45 years of record (1928-1973), Ohio River flow at Louisville, Kentucky averaged 113,700 cubic feet per second (cfs), representing a yield of 16.73 inches from the watershed (U.S. Department of Interior 1976). The maximum discharge into the river at Louisville was

Table 3.4-1. Principal Tributaries of the Ohio River

Tributary	Confluence at Miles Below Pittsburgh	Length of Main Stream (mi)	Drainage Area (mi^2)	Average Slope (ft/mi)
Alleghney	0	325	11,700	2.7
Monongahela	0	128	7,380	1.15
Beaver	25.4	21	3,130	4.1
Muskingum	172.2	112	8,040	1.5
Little Kanawha	184.6	160	2,320	9.0
Hocking	199.3	100	1,190	4.5
Kanawha	265.7	97	12,200	1.4
Guyandotte	305.2	166	1,670	6.3
Big Sandy	317.1	27	4,280	1.2
Scioto	356.5	237	6,510	2.4
Little Miami	464.1	90	1,760	7.3
Licking	470.2	320	3,670	1.7
Great Miami	491.1	161	5,400	3.6
Kentucky	545.8	255	6,970	0.8
Salt	629.9	125	2,890	6.1
Green	784.2	370	9,230	2.0
Wabash	848.0	475	33,100	1.5
Saline	867.3	27	1,170	--
Tradewater	873.4	110	1,000	--
Cumberland	920.4	693	17,920	1.3
Tennessee	934.5	652	40,910	--
Mouth of Ohio	981.0	981	203,980	0.4

Source: Ohio River Basin Commission (1978).


NEW YORK
PENNSYLVANIA
OHIO
MARYLAND
WEST VIRGINIA
INDIANA
ILLINOIS
KENTUCKY
VIRGINIA
TENNESSEE
NORTH CAROLINA
Indianapolis
Columbus
Cincinnati
Frankfort
Louisville
Charleston
Pittsburgh
Nashville
LOWER OHIO MAIN STEM SUBREGION

SOURCE: Ohio River Basin Commission (1978)

Figure 3.6-1. Ohio River Basin

Table 3.4-2. Subregions of the Ohio River Basin

ID Number	Subregion	Drainage Area (sq mi)
501	Allegheny	11,700
502	Monongahela	7,380
503	Upper Ohio Main Stem	13,380
504	Muskingum	8,040
505	Kanawha	12,200
506	Scioto	6,510
507	Big Sandy/Guyandotte	5,950
508	Great Miami	5,400
509	Middle Ohio Main Stem	9,050
510	Kentucky/Licking	10,640
511	Green	9,230
512	Wabash	33,100
513	Cumberland	17,920
514	Lower Ohio Main Stem	12,570
	Total	163,070

Source: Ohio River Basin Commission (1978)

Table 3.4-3. Tributaries of the Ohio River within the Project Area

Tributary	River Mile
Lick Run (Kentucky)	[illegible]
Sinking Creek (Kentucky)	701.0
Bear Creek (Indiana)	702.3
Fanny Creek (Indiana)	703.9
Buck Creek (Indiana)	704.2
[illegible] Creek (Indiana)	705.1
Sample Run (Indiana)	706.1
[illegible] Run (Indiana)	707.4
Town Creek (Kentucky)	707.5
Bull Creek (Kentucky)	707.5
[illegible] Creek (Kentucky)	709.0
Clover Creek (Kentucky)	711.0
[illegible] Creek (Kentucky)	712.5
[illegible] Run (Indiana)	714.5
Sandy Branch (Indiana)	715.4
[illegible] Creek (Indiana)	717.2
Bear Creek (Indiana)	718.8
Indian Creek (Kentucky)	721.5
[illegible] (Indiana)	723.8
[illegible] Creek (Kentucky)	726.5

Source: USGS 7.5-minute series topographic maps

1,110,000 cfs on January 26 and 27, 1937, when the river stage rose to 85.44 feet. The historic minimum discharge was 2,100 cfs on August 12, 1930, prior to construction of the present system of dams.

Flow of the river in the project area has been assumed equivalent to that at the Louisville streamgage station (Table 3.4-4) because there are no large tributaries between the Kentucky River, upstream from Louisville, and the Green River, more than 60 miles downstream from the project area. However, 3 years (1977-1979) of data from the Ohio River Valley Water Sanitation Commission (ORSANCO) monitoring station at the Cannelton Lock and Dam show an average flow of 151,400 cfs, which is approximately 40,000 cfs higher than historic average flow at Louisville:

Ohio River Flow at RM 720.7 (Cannelton Dam)

Year	Average cfs for 12 Months Based on Monthly Means
1977	115,750
1978	150,166
1979	169,876

Average flow for 3 years: 151,417 cfs

Data compiled by the COE prior to 1970 estimated the natural 7-day 10-year (7Q10) low flow (week-long low flow with an expected natural recurrence once in a 10-year period) in the project area to be 5,880 cfs (Table 3.4-4). The augmented 7Q10 low flow is estimated to be 12,975 cfs. The augmented low flow, which is the existing low flow, reflects the effects of reservoirs on the river and is approximately double the natural 7Q10 low flow. In several reaches of the river, the augmented 7Q10 low flow estimate is below ORSANCO's critical flow used to predict compliance with water quality standards. Average flow and augmented 7Q10 low flow estimates for the entire Ohio River are graphically presented in Figure 3.4-2.

3.4.1.1.2 Water Demand

Mid-1970 water demands from the major tributaries and various reaches of the Ohio River in the Basin totaled 2909 cfs (Table 3.4-4). Navigation requirements are 1,300 cfs at Pittsburg and 2,300 cfs at Louisville and the project area. Projections of the Ohio River Basin Commission (ORBC 1978) show an increase in water demands to 6663 cfs by 2000 and to 12,427 cfs by 2020. Consumptive withdrawals from the reach of the river including the project area will increase more than from the river as a whole; 71 cfs in 1975, 215 cfs by 2000, and 734 cfs by 2020 (Table 3.4-4). Overall, the ORBC projects an ample water supply in the Ohio River to provide for the amount of consumptive water use for the entire Ohio River Basin for the year 2020. The Commission also indicates that despite a rather large average annual flow compared with demand, water in the Basin is not unlimited and future consumption could cause problems with water quality.

Future flow balance in the Ohio River prior to its confluence with the Tennessee River is shown in Figure 3.4-3. According to the ORBC, the effects of consumptive use increases on navigation and water supply will not be significant. Further, the effects on water availability for aquatic biota, wildlife, and recreation will not be significant, primarily because the present system of locks and dams maintain pool levels that have sufficient surface

Table 3.4-4. Ohio River Flow and Summary of Consumptive Water Use, 1975, 2000, and 2020

Tributary or Ohio River Reach and Miles	Ohio River Flow (cfs)				Consumption (cfs)			
	Average Flow	Natural 7-Day/10-Yr Low Flow[1]	Augmented 7-Day/10-Yr Low Flow[1]	Water Quality Critical Flow[2]	Total 1975	Total 2000	Total 2020	Navigation
Allegheny	19,100				175	333	340	
Monongahela	12,260		1,010		932	1,232	1,704	
Ohio River 0-25.0	32,470	1,850	5,050	4,600	29	34	39	1,300
Beaver	8,380	232	325		212	312	425	
Ohio River 25.0-100.0	40,850	2,180	5,640	5,500	102	295	692	
Ohio River 100.0-161.7 (Willow Island Dam)	40,850	2,180	5,640	6,600	22	79	610	
Ohio River 161.7-172.2	40,850	2,180	5,640	7,700				
Muskingum	9,880	565	613		101	150	220	
Ohio River 172.2-265.2	50,730	2,980	6,850	7,700	18	200	536	
Kanawha	26,890	1,285	1,505		362	509	886	
Ohio River 265.2-279.2 (Gallipolis Dam)	77,620	3,840	8,550	7,700				
Ohio River 279.2-317.1	77,620	3,840	8,550	9,900	20	37	511	
Big Sandy and Guyandotte	2,370	59	65		30	87	63	
Ohio River 317.1-356.5	79,900	3,969	8,754	9,900	52	150	257	
Scioto	11,560	184	312		66	167	269	
Ohio River 356.5-436.2 (Meldahl Dam)	91,550	4,600	9,750	9,900	5	310	929	
Ohio River 436.2-491.1	96,810	4,960	10,750	12,100	54	70	163	
Great Miami and Little Miami	11,480	323	478		108	315	333	
Ohio River 491.1-545.8	108,290	5,586	12,263	12,100	18	63	545	
Kentucky and Licking	5,410	163	189		48	129	109	
Ohio River 545.8-605.8 (McAlpine Dam)	113,700	5,880	12,975	12,100	41	199	622	2,300
Ohio River 605.8-784.2[3]	113,700	5,880	12,975	14,300	71	215	734	
Green	20,200	306	373		47	64	81	
Ohio River 784.2-846.0 (Uniontown Dam)	133,900	7,000	15,400	14,300	11	102	235	
Wabash	23,670	2,250	2,604		281	1,085	1,570	
Ohio River 848.0-918.5 (Smithland Dam)	157,570	8,900	20,344	20,000	6	217	391	
Ohio River 918.5-920.4	157,570	8,900	20,344	48,500				
Cumberland	31,150	810	4,100		71	285	139	
Ohio River 920.4-934.5	188,720	9,470	28,069	48,500	1	1	2	
Tennessee[4]	69,790	810	10,000		(402)	(1,427)	-	
Ohio River 934.5-981.0	258,500	16,500	46,300	48,500	26	23	22	
Total (ORB)					2,909	6,663	12,427	

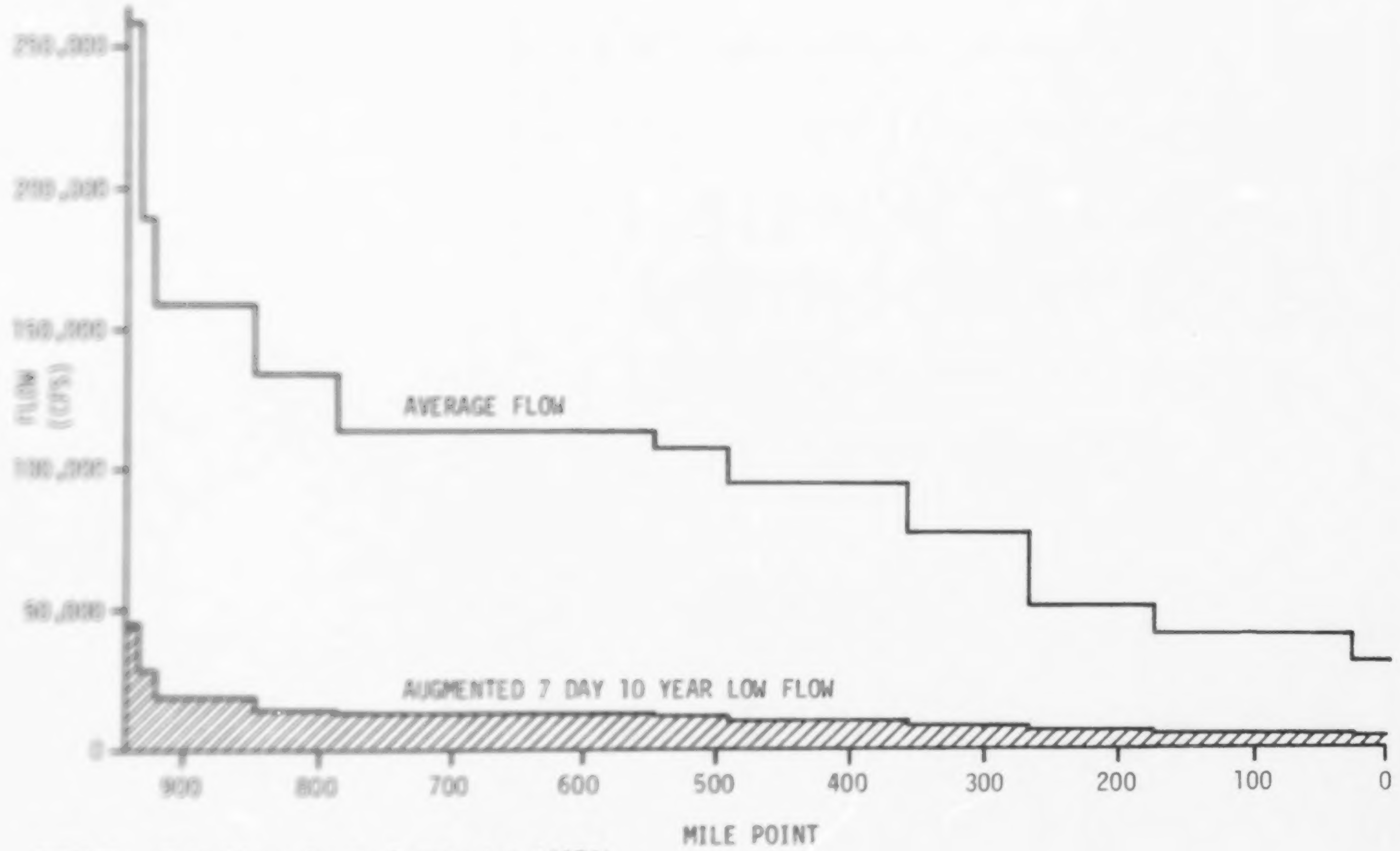
[1] 10-Year Frequency Flow Study, COE (1970).

[2] ORSANCO's critical flow for water quality standards.

[3] Reach of the river containing the Louisville stream gauge station (RM 607.3) and the project area (RM 702-722). The Cannelton Dam was not operating during these years of record.

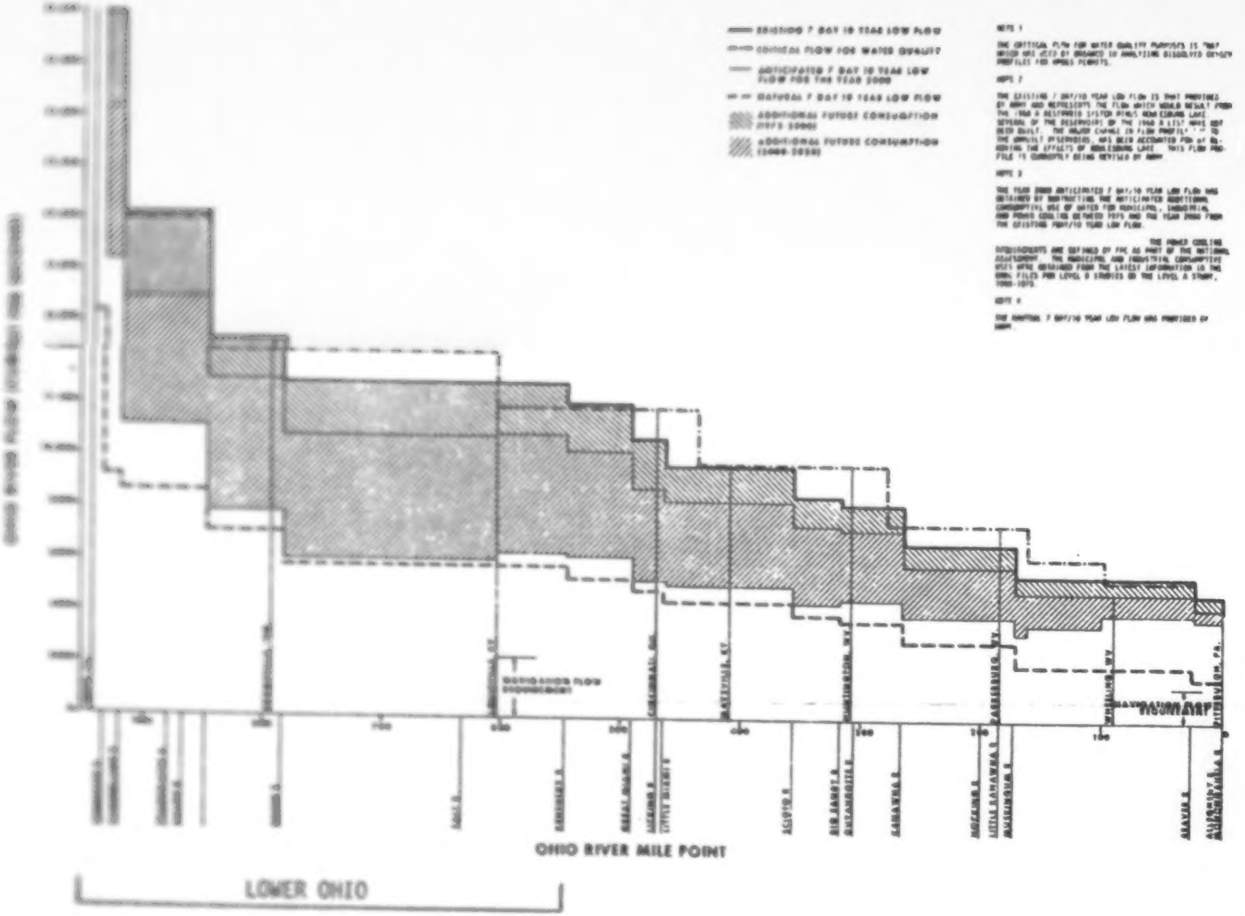
[4] Not included in consumptive use totals for the Ohio River Basin (ORB).

Source: Ohio River Basin Commission (1970).



SOURCE: Ohio River Basin Commission (1978)

Figure 3.4-2. Ohio River Flows, 1978



SOURCE: Ohio River Basin Commission (1978)

Figure 3.4-3. Ohio River Flow Balance, Ohio River Basin, 1978

water for recreation and ample depth for fish and wildlife. The primary concern in the ORBC view of the future condition of the Ohio is that water quality must be maintained in order to preclude significant effects on recreation, fish, and wildlife. A dissolved oxygen profile modeled by ORSANCO shows no water quality problems by 2000, but the reduced low flow projected for 2020 might produce water quality problems from below Cincinnati to Louisville and from above Evansville, Indiana to the confluence of the Cumberland River east of Paducah. The effects of consumptive use on the major tributaries are included in ORSANCO's models.

The largest consumer of Ohio River water presently is industry other than power plants and synfuel plants (Table 3.4-5). The ORBC projects that by 2000, power plants will be a larger consumer than all other industry, and synfuel plants will increase from zero consumption in the mid-1970s to 364 cfs in 2000. By 2020, the Commission predicts that power plants will be a larger consumer than all other users combined, including municipal, other industry, and agriculture. Power plant consumption rates are: 512 cfs in 1975, 2497 cfs by 2000 and 6419 cfs by 2020. The projected increases in water demand for municipal use and for industrial use other than power plants and synfuel plants are believed by the Commission to be too high because they are based on growth patterns of the 1960s, which slowed in the 1970s. Projections for electrical power and synfuel industries demand are based on Federal DOE assessments and are considered more accurate, although actual consumption may be higher because once-through cooling was still a consideration at the time of the study. Additionally, based on current (1980) Kentucky DOE predictions of synfuel development in Kentucky, synfuel industry projections may be too low and could, along with possible greater power plant consumption, offset the high projections for municipal and other industry consumptive uses.

To mitigate the effects of increased water demand in the Ohio River Basin, the ORBC suggested several alternatives available to the states to lessen effects on tributaries and to the Basin as a whole to lessen effects on the Ohio River main stem. One is to have all Basin states adopt low flow policies as Indiana and Pennsylvania now have, which prevent new consumptive use at or below the existing 7Q10 low flow. New large consumers in these states are required to develop reservoir storage to meet their demands during droughts. Other alternatives included not requiring offstream cooling for power plants along the river, which would save 1000 cfs by 2000; requiring higher levels of wastewater treatment at all sewage treatment facilities along the river, which is expected to be automatic for renewal of NPDES permits if predicted low flows are realized; constructing new reservoirs to provide low flow augmentation, which probably will be done for flood control as well; restricting growth in population and energy consumption, which the ORBC believes would only delay problems; encouraging development of water and energy conservation programs, including magnetohydrodynamic generation of electricity, which would double the power produced from each ton of coal; and changing operating schedules and/or storage allocations of existing reservoirs, which could develop as much as 150,000 acre-feet of storage according to COE estimates.

The option of not requiring offstream cooling appears to be unfavorable to some federal agencies. Nevertheless, efforts to reduce the effects of increased consumption on low flows appear to have been successful via construction of or plans for new reservoirs. Assuming completion of reservoirs planned through 1985, the COE now projects a 7Q10 low flow at Louisville of 16,200

Table 3.4-5. Consumptive Water Use, Ohio River Basin, 1975, 2000, and 2020

Tributary or Ohio River Reach	1975 Consumption (cfs)						2000 Consumption (cfs)						2020 Consumption (cfs)					
	Municipal1/	Industrial	Agriculture	Power	Synthetic Fuel	Total	Municipal1/	Industrial	Agriculture	Power	Synthetic Fuel	Total	Municipal1/	Industrial	Agriculture	Power	Synthetic Fuel3/	Total
Allegheny	48	55	4	64	–	175	63	86	13	155	16	333	86	130	18	106		340
Monongahela	31	825	4	71	–	932	41	1,109	8	74	–	1,232	55	1,591	12	46		1,704
Ohio River [illegible]	7	21	1	–	–	29	10	22	2	–	–	34	12	23	4	–	–	39
Beaver	15	169	5	23	–	212	16	259	14	23	–	312	26	376	22	1		425
Ohio River [illegible]	5	41	4	52	–	102	5	41	5	244	–	295	5	41	12	594	40	692
Ohio River [illegible] (Willow Island Dam)	1	17	4	–	–	22	1	17	5	56	–	79	1	17	12	580		610
Ohio River [illegible]				–	–					–	–					–		
Muskingum	27	17	17	40	–	101	41	31	35	43	–	150	55	48	51	66		220
Ohio River [illegible]	2	1	5	10	–	18	3	2	7	128	60	200	5	3	15	453	60	536
Kanawha2/	18	295	9	40	–	362	27	438	15	29	–	509	38	632	22	194		886
Ohio River [illegible] (Gallipolis Dam)				–	–					–	–					–		
Ohio River [illegible]	3	2	3	12	–	20	3	2	4	–	28	37	3	2	8	498		511
Big Sandy and Guyandotte	7	33	7	11	–	30	7	17	3	60	–	87	8	27	4	24		63
Ohio River [illegible]	3	47	2	–	–	52	3	47	3	97	–	150	3	47	6	201		257
Scioto River	22	15	27	2	–	66	35	30	102	0	–	167	46	51	153	19		269
Ohio River [illegible] (Meldahl Dam)	1	0	4	–	–	5	1	0	6	283	20	310	2	0	13	914		929
Ohio River [illegible]	21	7	2	18	–	54	43	10	4	13		70	52	11	8	92		163
Great Miami and Little Miami	36	38	33	5	–	108	56	57	118	84	–	315	71	85	174	3		333
Ohio River [illegible]	1	4	3	10	–	18	1	9	4	49	–	63	2	14	9	520		545
Kentucky and Licking	12	1	33 4/	2	–	48	20	2	62 4/	45	–	129	37	4	68 4/	–		109
Ohio River [illegible] (McAlpine Dam)	29	14	3	–	–	41	37	24	4	134	–	199	52	29	10	531		622
Ohio River [illegible]	5	9	9	48	–	71	9	16	13	157	20	215	13	20	28	653	20	734
Green	6	1	11	29	–	47	11	2	14	37	–	64	18	5	17	41		81
Ohio River [illegible] (Uniontown Dam)	3	2	3	1	–	11	6	3	4	9	80	102	6	4	10	135	80	235
Wabash	22	52	120	37	–	201	117	101	369	498	–	1,085	171	180	738	421	60	1,570
Ohio River [illegible] (Smithland Dam)	1	1	4	–	–	6	2	1	5	69	140	217	2	1	11	317	60	391
Ohio River [illegible]			–	–	–				0	–	–				0	–		
Cumberland	25	11	19	16	–	71	42	20	28	195	–	285	69	35	35			139
Ohio River [illegible]	–	–	1	–	–	1	–	–	1	–	–	1	–	–	2	–		2
Tennessee5/	(50)	(286)	(11)	(88)	–	(402)	(110)	(660)	(28)	(623)	–	(1,427)						
Ohio River [illegible]	1	2	2	21	–	26	2	3	3	16	–	23	2	3	7	10		22
Total (ORB)	405	1,654	330	512	–	2,909	602	2,349	851	2,497	364	6,663	840	3,379	1,469	6,419	320	12,427

1/Includes rural [illegible]. The Ohio River Basin Commission (1979) believes projections for municipal and industrial consumptive uses are too high.

2/Includes Little Kanawha.

3/[illegible] River only.

4/Includes [illegible].

5/Not included in totals for the Ohio River Basin (ORB).

Source: Ohio River Basin Commission (1979).

cfs, which is 1,225 cfs above the 7Q10 low flow estimated using pre 1970 data. The corresponding estimate of 30-day, 10-year (30Q10) low flow is 13,750 cfs. Seven-day low flow estimates for Louisville (and the project area) are:

Recurrence Interval (years)	River Flow (cfs)
2	18,300
5	15,500
10	14,200
20	13,100
50	12,000
100	11,200
200	10,700

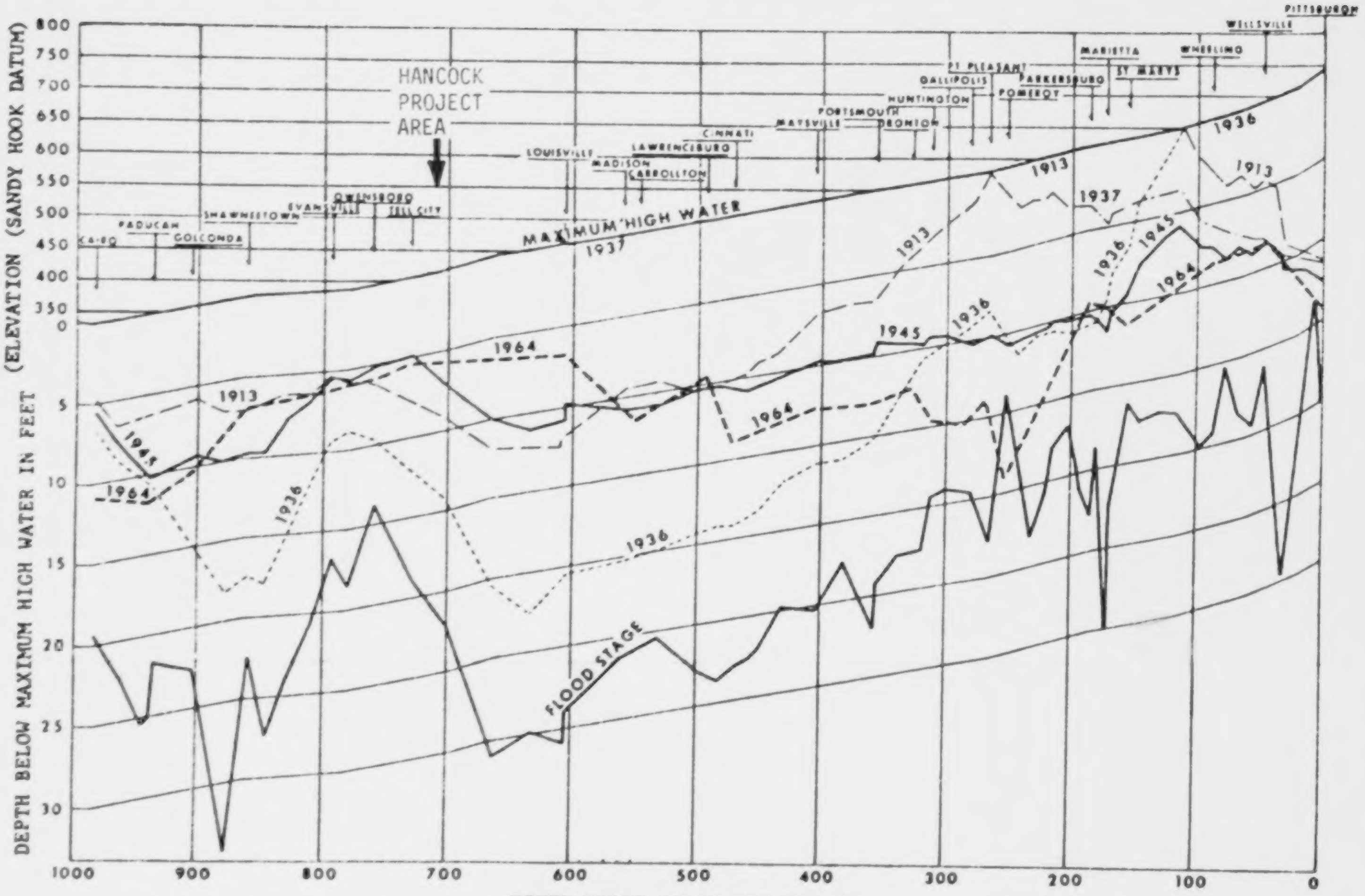
3.4.1.1.3 Floods

Floods are a recognized hazard along the Ohio River. Historically, December through April is flood season on the river, with greatest floods occurring from January through March. Although specifically for maintaining a navigation channel, the present lock and dam system serves to reduce flood elevations 2 to 3 feet for the 100-year flood level.

Five major floods of record have affected the Ohio River main stem: March 1913, March 1936, January-February 1937, March 1945, March 1964 (Figure 3.4-4). The flood of record is the 1937 event, which caused maximum recorded stages in a 705-mile reach of the river, from Point Pleasant, West Virginia to the Mississippi River. Record stages also occurred on the Cumberland River 160 miles upstream and on the lower reaches of the Green and Kentucky rivers. The flood stage at Cincinnati was exceeded for 19 days. The maximum discharge at Louisville was 1,110,000 cfs.

Prior to the flood of record, the March 1913 flood caused a peak discharge at Pomeroy, Ohio, of 633,000 cfs. This flood originated in the northern watersheds of the river, from the Beaver River to the Wabash River. In March 1936, storms in the Monongahela and Allegheny watersheds caused record stages on the first 115 miles of the Ohio main stem, from Pittsburgh to 20 miles below Wheeling, West Virginia. Upstream, record stages occurred for 45 miles of the Allegheny and 23 miles of the Monongahela.

Since the flood of record, March 1945 flood stages were second highest recorded at Louisville. This flood affected the entire main stem but was most severe, and increasingly so, from Pittsburgh to Louisville. Construction of several reservoirs in the Allegheny, Monongahela, Beaver and Muskingum watersheds reduced flood stages in the upper reaches of the Ohio, while lack of such an extensive reservoir system in the watersheds below Marietta, Ohio resulted in the severe flood stages at Louisville. Below Louisville, flood stages were of no significant record. The March 1964 flood was the maximum of record in the Licking and Little Miami watersheds. A larger system of reservoirs over the Ohio Basin abated flood stages but could have been more limiting had the storms mostly been centered upstream from them rather than downstream. Paducah recorded 10 inches of rain and Louisville recorded 13 inches during the 1964 flood.



SOURCE: Ohio River Basin Commission (1978)

Figure 3.4-4. Relative Flood Stage Profiles, Ohio River, 1978

Ohio River Basin Commission (1978) has related historic and current effects of flooding to costs of damages. The natural average annual damages in the Ohio River floodplain amount to $181.2 million, of which $146.8 million has been or will be abated by existing and underway projects. Damages along the river are the greater proportion (68%) of all damages in the Ohio River Basin and abatement proportion along the river is considerably greater than along the tributaries (81% vs. 53%). To address all but about 17% of the natural average annual damages in the Basin, the ORBC has identified 62 projects they recommend for implementation and another 40 to be studied for determination of recommendation. Most of these projects involve land treatment of some kind and a few are reservoirs. None is near either the Hancock or Breckinridge site, although 3 of the underway projects are in the Hancock/Perry County area below the Hancock site.

3.4.1.1.4 Water Quality

Water quality control in the Ohio River Basin began in 1948 with the formation of the Ohio River Valley Water Sanitation Commission (ORBC 1978). ORSANCO was charged with implementing a coordinated program (among the Basin states and Federal government) designed to improve Ohio River water quality for purposes of water supply, recreation, and fish and wildlife resources. Wastewater treatment was emphasized and wastewater standards applicable to discharges into the Ohio River were developed (Subsection 1.3.2.8.6.3; Table 1.3-9). Concurrently, low flow augmentation increased with development of large reservoirs, and the combined net effect of reservoirs and especially wastewater control programs has produced an improvement in water quality.

ORSANCO currently monitors water quality at several stations along the Ohio River, including the Cannelton Dam. The United States Geological Survey (USGS) also monitors water quality at the Cannelton Dam and other parts on the river. ORSANCO publishes a monthly summary of their data, while USGS data are published annually in the Water Resources Data for Kentucky.

Based on ORSANCO and other data, as well as a special assessment ORSANCO conducted for the Commission, the ORBC (1978) reports that no major existing problem on the Ohio River is apparent relative to dissolved oxygen (DO), temperature, conductivity, and pH; taste and odor problems are localized. To maintain and improve the contribution of reservoirs to water quality the ORBC has recommended that the COE continue activities that achieve maximum reaeration of impounded water. ORSANCO will continue emphasizing wastewater treatment processes and water pollution control assessments.

The ORBC includes barium, cadmium, chloride, chromium, copper, iron, manganese, phosphorous, selenium, silver, and zinc among the inorganic chemical parameters that cause no major water quality problem, although several of these may be above drinking water or aquatic life standards in the project area (see Table 1.3-10 and the next subsection). Cyanide and mercury are considered problems in the Upper Ohio river and lead is considered a problem in the Upper and Middle portions of the river. The Commission's limited organic chemical data indicate phenol problems throughout much of the river. Biological parameters examined by the Commission show that fecal coliform levels are not meeting stream standards and are increasing in many locations, despite higher levels of treatment and disinfection; mercury, PCB's, and chlordane levels are above acceptable levels in fish tissues at some locations; fish in localized areas are declining in weight and numbers; but pollution-sensitive fish are increasing in numbers in several areas of the river. The Commission has recommended studies and/or actions that will help solve these problems.

3.4.1.1.4.1 Water Quality Analyses, Ohio River Miles 702 to 722

Limited water quality sampling in that part of the Ohio River included in the project area indicated that manganese may consistently exceed ORSANCO standards and Kentucky water quality criteria for a drinking water supply source (Tables 3.4-6 and 1.3-9). Mercury was near or somewhat above Kentucky's recommended limit for drinking water supply during spring 1980. All other metals analyzed were within acceptable ORSANCO and Kentucky limits, although Storet data used to develop Table 1.3-10 indicate several other parameters may be above standards. Temperature and dissolved oxygen profiles showed a well mixed system at all locations sampled (Table 3.4-7). No thermal stratification was observed and no dissolved oxygen (DO) depletion with depth was noted. All temperature and DO values were within current standards set by ORSANCO and the Commonwealth of Kentucky.

Table 3.4-6. Metals Analyses (mg/1), Ohio River Miles 705, 717, and 722, 1979-1980

	September 1979			May 1980		
Parameter	RM 705	RM 717	RM 722	RM 705	RM 717	RM 722
Iron (Fe)	1.24	0.83	1.57	1.30	1.10	3.20
Zinc (Zn)	0.07	<0.01	0.03	0.024	0.027	0.046
Nickel (Ni)	0.046	0.028	0.022	0.005	0.005	0.005
Silver (Ag)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium (Se)	<0.001	<0.001	<0.001	0.016	0.015	0.012
Cadmium (Cd)	0.005	<0.001	<0.001	0.003	0.004	0.003
Chromium (Cr) (Total)	<0.001	<0.001	0.002	<0.001	<0.001	0.007
Copper (Cu)	0.005	<0.005	<0.005	0.056	0.030	0.046
Lead (Pb)	0.004	0.003	0.005	0.003	0.004	0.008
Manganese (Mn)	0.047	0.044	0.091	0.100	0.075	0.400
Mercury (Hg)	<0.0005	<0.0005	<0.0005	0.0018	0.0016	0.0026
Barium (Ba)	0.03	0.04	0.05	0.08	0.10	0.13
Arsenic (As)	<0.0005	<0.0005	<0.0005	0.014	0.015	0.027

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.4-7. Temperature and Dissolved Oxygen Profiles, Ohio River Miles 705, 707, 715, 717, and 722, 1979-1980 (Sheet 1 of 5)

Relative Distance from Kentucky Shore

Depth (meters)	20% Temp (°C)	20% D.O. (mg/l)	40% Temp (°C)	40% D.O. (mg/l)	50% Temp (°C)	50% D.O. (mg/l)	60% Temp (°C)	60% D.O. (mg/l)	80% Temp (°C)	80% D.O. (mg/l)
RM 705, July 9, 1979										
1	23.9	7.2	[illegible]	7.2	24.0	7.2	24.0	7.1	23.9	7.2
2	23.9	7.2	24.0	7.2	24.0	7.2	24.0	7.1	23.9	7.2
3	23.9	7.2	24.0	7.2	24.0	7.2	24.0	7.1	23.9	7.2
4			23.9	7.2	24.0	7.2	23.9	7.1	23.9	7.2
5			23.9	7.1	23.9	7.2	23.9	7.1		
6			23.9	7.1	23.9	7.2	23.9	7.1		
7			23.9	7.1	23.9	7.2	23.9	7.1		
8					23.9	7.1	23.9	7.1		
9					23.9	7.1	23.9	7.1		
10					23.9	7.1				
11					23.9	7.1				
12					23.9	7.1				
13					23.9	7.1				
14										
15										
RM 707, July 9, 1979										
1	23.8	7.2	23.9	7.3	24.0	7.2	24.0	7.1	24.1	7.2
2	23.8	7.2	23.9	7.3	24.0	7.1	24.0	7.1	24.0	7.2
3	23.8	7.2	23.9	7.3	24.0	7.1	24.0	7.1	24.0	7.2
4			23.9	7.3	23.9	7.1	23.9	7.1	24.0	7.2
5			23.9	7.1	23.9	7.1	23.8	7.1		
6					23.9	7.1	23.9	7.1		
7					23.9	7.1	23.9	7.1		
8					23.8	7.1	23.9	7.1		
9					23.8	7.1	23.9	7.1		
10					23.8	7.1	23.9	7.1		
11					23.8	7.1				
12					23.8	7.1				
13					23.8	7.1				
14										
15										

Relative Distance from Kentucky Shore

Depth (meters)	20% Temp (°C)	20% D.O. (mg/l)	40% Temp (°C)	40% D.O. (mg/l)	50% Temp (°C)	50% D.O. (mg/l)	60% Temp (°C)	60% D.O. (mg/l)	80% Temp (°C)	80% D.O. (mg/l)
RM 715, July 9, 1979										
1	[illegible]	[illegible]	24.3	7.4	24.3	7.3	24.4	7.3	24.4	7.4
2	[illegible]	[illegible]	24.3	7.4	24.3	7.3	24.4	7.3	24.4	7.4
3	[illegible]	7.4	24.3	7.4	24.3	7.3	24.3	7.3	24.4	7.4
4	[illegible]	7.4	24.3	7.4	24.3	7.3	24.3	7.3		
5			24.3	7.4	24.3	7.3	24.3	7.3		
6			24.3	7.4	24.3	7.3	24.3	7.3		
7			24.3	7.3	24.2	7.3	24.3	7.3		
8			24.3	7.3	24.2	7.3	24.3	7.2		
9					24.2	7.3	24.3	7.2		
10					24.2	7.3	24.3	7.2		
11					24.2	7.3				
12					24.2	7.3				
13					24.2	7.3				
14										
15										
RM 717, July 9, 1979										
1	24.5	7.5	24.5	7.6	24.5	7.5	24.5	7.5	24.4	7.6
2	24.5	7.5	24.5	7.6	24.5	7.5	24.5	7.5	24.4	7.6
3	24.4	7.6	24.5	7.6	24.5	7.5	24.5	7.5	24.4	7.6
4			24.4	7.5	24.5	7.5	24.4	7.5	24.4	7.6
5			24.4	7.5	24.5	7.5	24.4	7.5	24.4	7.6
6			24.4	7.5	24.5	7.5	24.4	7.5		
7			24.4	7.5	24.5	7.4	24.4	7.5		
8			24.3	7.4	24.4	7.4	24.4	7.5		
9			24.3	7.4	24.4	7.4	24.4	7.5		
10			24.3	7.4	24.4	7.4	24.4	7.5		
11			24.3	7.4	24.4	7.4				
12			24.3	7.4	24.3	7.4				
13					24.3	7.4				
14					24.3	7.4				
15					24.3	7.4				

Relative Distance from Kentucky Shore

Depth (meters)	20% Temp (°C)	20% D.O. (mg/l)	40% Temp (°C)	40% D.O. (mg/l)	50% Temp (°C)	50% D.O. (mg/l)	60% Temp (°C)	60% D.O. (mg/l)	80% Temp (°C)	80% D.O. (mg/l)
RM 722, July 9, 1979										
1	[illegible]	8.4	24.2	8.0	24.2	8.0	24.3	8.0	24.0	7.9
2	24.2	8.2	24.2	8.0	24.2	8.0	24.3	8.0	24.0	7.9
3	24.2	8.0	24.2	7.9	24.2	8.0	24.2	7.9	24.0	7.9
4	24.1	7.9	24.2	7.9	24.2	8.0	24.1	7.9	24.0	7.9
5	24.1	7.9	24.2	7.8	24.2	7.9	24.1	7.9	24.0	7.8
6			24.1	7.8	24.2	8.0	24.1	7.9	24.0	7.8
7			24.1	7.8	24.2	7.9	24.1	7.9	24.0	7.8
8			24.0	7.8	24.1	7.9	24.0	7.9	24.0	7.8
9			24.0	7.8	24.1	7.9	24.0	7.9	24.0	7.8
10					24.1	8.0	24.0	7.8	24.0	7.8
11					24.1	7.9	24.0	7.8		
12					24.0	7.8	24.0	7.8		
13					24.0	7.8	24.0	7.8		
14					24.0	7.8	24.0	7.8		
15					24.0	7.8				
RM 705, July 23, 1979										
1	24.2	6.9	24.3	6.9	24.4	6.9	24.4	6.9	24.5	6.8
2	24.2	6.9	24.3	6.9	24.4	6.9	24.4	6.9	24.5	6.8
3	24.2	6.9	24.3	6.9	24.4	6.9	24.4	6.9	24.5	6.8
4	24.2	6.9	24.3	6.9	24.4	6.9	24.4	6.9	24.4	6.8
5			24.2	6.9	24.4	6.9	24.4	6.9	24.4	6.8
6			24.2	6.8	24.4	6.9	24.4	6.9		
7			24.2	6.8	24.4	6.8	24.4	6.9		
8			24.2	6.8	24.4	6.8	24.3	6.9		
9			24.2	6.8	24.4	6.8	24.3	6.8		
10					24.3	6.8	24.3	6.8		
11					24.3	6.8	24.3	6.8		
12					24.3	6.8				
13					24.3	6.8				
14										
15										
16										

Relative Distance from Kentucky Shore

Depth (meters)	20% Temp (°C)	20% D.O. (mg/l)	40% Temp (°C)	40% D.O. (mg/l)	50% Temp (°C)	50% D.O. (mg/l)	60% Temp (°C)	60% D.O. (mg/l)	80% Temp (°C)	80% D.O. (mg/l)
RM 707, July 23, 1979										
1	24.4	6.9	24.4	6.9	[illegible]	[illegible]	[illegible]	6.9	[illegible]	6.9
2	24.4	6.9	[illegible]	[illegible]	24.4	[illegible]	[illegible]	[illegible]	[illegible]	6.9
3	24.4	6.8	24.3	6.9	24.4	6.9	[illegible]	6.8	[illegible]	6.9
4			24.3	6.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.9
5			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.9
6					[illegible]	[illegible]	[illegible]	[illegible]		
7					[illegible]	[illegible]	[illegible]	[illegible]		
8					[illegible]	[illegible]	[illegible]	[illegible]		
9					[illegible]	[illegible]	[illegible]	[illegible]		
10					[illegible]	[illegible]	[illegible]	[illegible]		
11					[illegible]	[illegible]				
12					[illegible]	[illegible]				
13										
14										
15										
16										
RM 715, July 23, 1979										
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	24.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
6			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
7					[illegible]	[illegible]	[illegible]	[illegible]		
8					[illegible]	[illegible]	[illegible]	[illegible]		
9					[illegible]	[illegible]				
10					[illegible]	[illegible]				
11					[illegible]	[illegible]				
12										
13										
14										
15										
16										

Relative Distance from Kentucky Shore

Depth (meters)	20% Temp (°C)	20% D.O. (mg/l)	40% Temp (°C)	40% D.O. (mg/l)	50% Temp (°C)	50% D.O. (mg/l)	60% Temp (°C)	60% D.O. (mg/l)	80% Temp (°C)	80% D.O. (mg/l)
RM 717, July 23, 1979										
1	[illegible]	[illegible]	24.5	[illegible]	24.6	6.8	[illegible]	[illegible]	24.5	6.9
2	[illegible]	[illegible]	24.5	[illegible]	24.6	[illegible]	[illegible]	6.9	24.5	6.9
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24.5	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24.4	[illegible]
5			24.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24.4	[illegible]
6			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
7			[illegible]	[illegible]	24.4	[illegible]	24.4	[illegible]		
8					24.4	[illegible]	24.4	[illegible]		
9					24.4	[illegible]	24.4	[illegible]		
10					24.4	[illegible]	24.4	[illegible]		
11					[illegible]	[illegible]	[illegible]	[illegible]		
12					24.4	6.7				
13					24.4	6.7				
14										
15										
16										
RM 722, July 23, 1979										
1	[illegible]	7.1	24.6	7.0	24.5	7.0	24.6	7.1	24.5	7.0
2	[illegible]	[illegible]	24.6	7.0	24.4	7.0	24.5	7.0	24.5	7.0
3	[illegible]	[illegible]	24.5	7.0	24.4	[illegible]	24.5	7.0	24.5	6.9
4			24.5	6.9	24.4	6.9	24.5	7.0	24.4	6.9
5			24.4	6.9	24.4	6.9	24.5	7.0	24.4	6.9
6			[illegible]	[illegible]	24.4	6.9	24.4	6.9		
7					24.4	6.9	24.4	6.9		
8					24.4	6.9	24.4	6.9		
9					24.4	6.9	24.4	6.9		
10					24.3	6.9	24.4	6.9		
11					24.3	6.9				
12					24.3	6.9				
13					24.3	6.9				
14					24.3	6.9				
15										
16										

Relative Distance from Kentucky Shore

Depth (meters)	20% Temp (°C)	20% D.O. (mg/l)	40% Temp (°C)	40% D.O. (mg/l)	50% Temp (°C)	50% D.O. (mg/l)	60% Temp (°C)	60% D.O. (mg/l)	80% Temp (°C)	80% D.O. (mg/l)
RM 705, August 7, 1979										
1	24.5	6.6	[illegible]	[illegible]	24.5	6.7	[illegible]	[illegible]	[illegible]	[illegible]
2	24.5	6.6	[illegible]	[illegible]	24.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	24.5	6.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	24.5	6.6	24.4	[illegible]	24.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6			[illegible]	[illegible]	24.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7					[illegible]	[illegible]	[illegible]	[illegible]	24.4	[illegible]
8					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9					[illegible]	[illegible]	[illegible]	[illegible]		
10					[illegible]	[illegible]	[illegible]	[illegible]		
11					[illegible]	[illegible]				
12					[illegible]	6.9				
RM 707, August 7, 1979										
1	24.8	6.7	24.7	6.7	[illegible]	6.7	[illegible]	6.7	24.8	6.7
2	24.8	6.7	[illegible]	6.7	[illegible]	6.7	24.8	6.7	24.8	6.7
3	24.8	[illegible]	[illegible]	6.7	[illegible]	6.7	[illegible]	6.7	24.8	6.7
4			24.7	6.7	[illegible]	6.7	24.7	6.7	24.8	6.7
5			24.7	6.7	[illegible]	6.7	24.8	6.7	24.8	6.7
6					24.7	6.7	[illegible]	6.7	24.8	6.7
7					24.7	6.7	24.8	6.7		
8					24.7	6.7				
9					[illegible]	[illegible]				
10					[illegible]	6.6				
11										
12										
13										

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Table 3.4-7. Temperature and Dissolved Oxygen Profiles, Ohio River Miles 705, 707, 715, 717, and 722, 1979-1980 (Sheet 5 of 5)

	Relative Distance from Kentucky Shore									
	20%		40%		50%		60%		80%	
Depth (meters)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)
RM [illegible], May [illegible], 1980										
1	[illegible]	[illegible]	[illegible]	[illegible]	21.8	8.8	[illegible]	[illegible]	21.8	8.7
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21.8	8.8
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.7	21.7	8.7	[illegible]	[illegible]
6	[illegible]	8.8	[illegible]	8.8	[illegible]	8.7	[illegible]	8.7		
8			[illegible]	8.7	21.7	[illegible]	[illegible]	8.7		
10					21.6	8.6	21.5	8.6		
12					21.4	8.4				
14										
16										

	Relative Distance from Kentucky Shore									
	20%		40%		60%		60%		80%	
Depth (meters)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)
RM [illegible], May [illegible], 1980										
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
8			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
10					[illegible]	[illegible]	[illegible]	[illegible]		
12							[illegible]	[illegible]		
14										
RM [illegible], May [illegible], 1980										
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
8					[illegible]	[illegible]	[illegible]	[illegible]		
10					[illegible]	[illegible]	[illegible]	[illegible]		
12							[illegible]	[illegible]		
14										
16										

	Relative Distance from Kentucky Shore									
	20%		40%		60%		50%		80	
Depth (meters)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)
RM 715, May 29, 1980										
1	21.7	8.7	21.7	8.6	21.7	8.7	21.6	8.6	21.7	8.7
2	21.7	8.7	21.7	8.6	21.7	8.7	21.6	8.6	21.7	8.7
4	21.7	8.7	21.5	8.7	21.7	8.7	21.4	8.6	21.7	8.7
6			21.4	8.7	21.4	8.7	21.4	8.6	21.7	8.7
8			21.5	8.7	21.4	8.7				
10					21.4	8.6				
12					21.4	8.6				
14										
16										
RM 717, May 29, 1980										
1	21.8	8.7	21.8	8.7	21.7	8.8	21.8	8.7	21.8	8.7
2	21.7	8.6	21.7	8.7	21.7	8.7	21.7	8.7	21.8	8.7
4	21.7	8.6	21.7	8.7	21.7	8.7	21.7	8.7	21.7	8.7
6			21.7	8.6	21.7	8.7	21.7	8.7	21.7	8.6
8			21.5	8.7	21.7	8.7	21.6	8.7		
10					21.5	8.7	21.6	8.7		
12					21.4	8.6				
14										
16										

	Relative Distance from Kentucky Shore									
	20%		40%		50%		60%		80%	
Depth (meters)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)
RM [illegible], June 6, 1980										
1	[illegible]	8.4	23.0	8.5	23.1	8.6	23.0	8.5	[illegible]	8.5
2	[illegible]	8.4	22.7	8.4	23.0	8.4	23.0	8.4	23.1	8.5
4	[illegible]	8.4	22.9	8.4	23.0	8.5	23.0	8.5	23.0	8.4
6			22.9	8.5	22.8	8.5	22.9	8.4		
8			22.8	8.4	22.8	8.5				
10					22.8	8.5				
12										
14										
16										
RM 707, June 6, 1980										
1	23.2	8.5	23.3	8.6	23.2	8.5	23.4	8.6	23.5	8.6
2	23.1	8.4	23.2	8.5	23.2	8.5	23.3	8.7	23.3	8.5
4	23.0	8.4	23.0	8.6	23.2	8.5	23.2	8.6	23.3	8.6
6	22.9	8.3	23.0	8.4	23.1	8.5	23.0	8.4		
8			22.8	8.4	23.0	8.4				
10					22.9	8.4				
12					22.2	8.4				
14										
16										

	Relative Distance from Kentucky Shore									
	20%		40%		50%		60%		40%	
Depth (meters)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)
RM 715, June 6, 1980										
1	[illegible]	[illegible]	[illegible]	8.6	[illegible]	8.7	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	8.6	23.6	8.7	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	8.5	23.6	8.7	[illegible]	[illegible]	[illegible]	[illegible]
6			[illegible]	[illegible]	23.6	8.7	[illegible]	[illegible]		
8					23.5	8.6	[illegible]	[illegible]		
10					23.4	[illegible]				
12					23.4	[illegible]				
14										
16										
RM [illegible], June 6, 1980										
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.6
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.6
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.6
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
8			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
10					[illegible]	[illegible]	[illegible]	[illegible]		
12										
14										
16										

	Relative Distance from Kentucky Shore									
	20%		40%		50%		60%		80	
Depth (meters)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)
RM 722, June 6, 1980										
1	23.8	8.7	23.6	8.7	23.7	8.6	23.6	8.7	23.6	8.7
2	23.8	8.6	23.8	8.6	23.6	8.6	23.5	8.6	23.6	8.6
4	23.6	8.6	23.8	8.6	23.5	8.5	23.6	8.6	23.5	8.6
6			23.6	8.5	23.5	8.5	23.4	8.6	23.5	8.6
8			23.6	8.5	23.5	8.5	23.4	8.6		
10					23.4	8.5	23.4	8.6		
12					23.4	8.5				
14										
16										

Source: Texas Instruments Incorporated field data (1979-1980).

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Table 3.4-7. Temperature and Dissolved Oxygen Profiles, Ohio River Miles 705, 707, 715, 717, and 722, 1979-1980 (Sheet 4 of 5)

Reproduced from best available copy.

Relative Distance from Kentucky Shore

Depth (meters)	20% Temp (°C)	20% D.O. (mg/l)	40% Temp (°C)	40% D.O. (mg/l)	50% Temp (°C)	50% D.O. (mg/l)	60% Temp (°C)	60% D.O. (mg/l)	80% Temp (°C)	80% D.O. (mg/l)
RM [illegible], April 17, 1980										
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
8			[illegible]	[illegible]	[illegible]	[illegible]				
10					[illegible]	[illegible]				
12					[illegible]	[illegible]				
14										
16										
RM [illegible], April 17, 1980										
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6					[illegible]	[illegible]	[illegible]	[illegible]		
8					[illegible]	[illegible]				
10					13.4	[illegible]				
12										
14										
16										

Relative Distance from Kentucky Shore

Depth (meters)	20% Temp (°C)	20% D.O. (mg/l)	40% Temp (°C)	40% D.O. (mg/l)	50% Temp (°C)	50% D.O. (mg/l)	60% Temp (°C)	60% D.O. (mg/l)	80% Temp (°C)	80% D.O. (mg/l)
RM 715, April 17, 1980										
1	14.2	9.2	14.3	9.0	14.2	9.1	14.1	9.1	14.2	9.2
2	14.0	9.0	14.2	[illegible]	14.1	8.9	14.0	9.1	14.1	8.9
4	13.9	9.0	14.1	9.0	14.0	8.8	13.7	8.9	[illegible]	8.9
6			13.9	9.0	13.7	8.8	13.6	8.8		
8			13.5	9.1	13.7	8.9	13.5	8.9		
10					13.4	8.9	13.5	8.9		
12					13.4	8.9				
14										
16										
RM 717, April 17, 1980										
1	14.4	9.1	14.3	9.1	14.5	9.0	14.4	9.2	14.6	9.2
2	14.1	9.1	14.0	9.1	14.0	9.0	14.1	9.2	14.0	9.0
4	13.6	9.0	14.0	9.1	14.0	9.0	14.0	9.0	13.9	9.0
6			14.0	9.1	13.8	8.9	13.8	9.0		
8			13.7	9.0	13.6	8.8				
10					13.2	8.7				
12										
14										
16										

Relative Distance from Kentucky Shore

Depth (meters)	20% Temp (°C)	20% D.O. (mg/l)	40% Temp (°C)	40% D.O. (mg/l)	50% Temp (°C)	50% D.O. (mg/l)	60% Temp (°C)	60% D.O. (mg/l)	80% Temp (°C)	80% D.O. (mg/l)
RM 722, April 17, 1980										
1	[illegible]	9.1	14.4	[illegible]	14.6	[illegible]	14.4	[illegible]	[illegible]	[illegible]
2	14.5	[illegible]	[illegible]	[illegible]	14.2	[illegible]	14.3	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	9.0	14.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6			13.9	9.0	14.1	9.0	14.0	[illegible]		
8					13.8	[illegible]	13.5	[illegible]		
10					13.6	[illegible]	13.7	[illegible]		
12					13.5	[illegible]				
14										
16										

Relative Distance from Kentucky Shore

Depth (meters)	20% Temp (°C)	20% D.O. (mg/l)	40% Temp (°C)	40% D.O. (mg/l)	50% Temp (°C)	50% D.O. (mg/l)	60% Temp (°C)	60% D.O. (mg/l)	80% Temp (°C)	80% D.O. (mg/l)
RM 705, May 15, 1980										
1	17.0	8.6	17.0	8.6	17.1	8.7	17.0	8.7	17.1	8.8
2	16.8	8.5	17.0	8.6	17.0	8.6	17.0	8.7	17.0	8.6
4			16.9	8.6	17.0	8.6	17.1	8.7	17.0	8.6
6					16.8	8.6	16.9	8.7	16.9	8.6
8					16.8	8.6	16.8	8.6		
10							16.8	8.6		
12										
14										
16										
RM 707, May 15, 1980										
1	17.2	8.8	17.3	8.8	17.3	8.9	17.2	8.8	17.2	8.8
2	17.2	8.8	17.3	8.8	17.3	8.9	17.2	8.8	17.2	8.7
4	17.2	8.8	17.3	8.7	17.1	8.8	17.2	8.7	17.0	8.7
6			17.2	8.7	17.1	8.8	17.2	8.7	16.8	8.7
8					16.9	8.8	16.9	8.7		
10					16.8	8.8				
12										
14										
16										

Relative Distance from Kentucky Shore

Depth (meters)	20% Temp (°C)	20% D.O. (mg/l)	40% Temp (°C)	40% D.O. (mg/l)	50% Temp (°C)	50% D.O. (mg/l)	60% Temp (°C)	60% D.O. (mg/l)	80% Temp (°C)	80% D.O. (mg/l)
RM 722, May 15, 1980										
1	17.4	8.9	17.5	8.9	17.7	8.8	17.8	8.7	17.7	8.8
2	17.4	8.9	17.4	8.9	17.7	8.8	17.8	8.7	17.6	8.8
4	17.4	8.8	17.4	8.8	17.4	8.8	17.6	8.7	17.6	8.8
6	17.4	8.8	17.4	8.8	17.4	8.6	17.6	8.6		
8					17.4	8.6	17.5	8.6		
10					17.5	8.6				
12					17.5	8.6				
14										
16										

Relative Distance from Kentucky Shore

Depth (meters)	20% Temp (°C)	20% D.O. (mg/l)	40% Temp (°C)	40% D.O. (mg/l)	50% Temp (°C)	50% D.O. (mg/l)	60% Temp (°C)	60% D.O. (mg/l)	80% Temp (°C)	80% D.O. (mg/l)
RM 715, May 15, 1980										
1	17.4	8.7	17.3	8.7	17.4	8.8	17.4	8.7	17.1	[illegible]
2	17.4	8.7	17.3	8.7	17.3	8.8	17.4	8.7	[illegible]	[illegible]
4	17.2	8.7	17.3	8.7	17.2	8.8	17.3	[illegible]	[illegible]	[illegible]
6			17.3	8.6	17.2	8.7	17.3	8.6		
8			[illegible]	8.6	17.2	8.6	[illegible]	8.6		
10					[illegible]	8.6				
12					[illegible]	8.6				
14										
16										
RM 717, May 15, 1980										
1	17.7	8.8	17.6	[illegible]	17.6	8.7	[illegible]	[illegible]	[illegible]	[illegible]
2	17.6	8.8	17.6	[illegible]	17.6	8.7	17.5	8.8	17.6	[illegible]
4	17.5	8.7	17.6	8.7	17.5	8.7	17.5	8.8	17.6	[illegible]
6			17.5	8.7	17.4	8.7	17.2	8.8		
8			17.5	8.7	17.4	8.6				
10					17.4	8.6				
12					17.4	8.6				
14					17.4	8.6				
16										

Table 3.4-7. Temperature and Dissolved Oxygen Profiles, Ohio River Miles 705, 707, 715, 717, and 722, 1979-1980 (Sheet 3 of 5)

Relative Distance from Kentucky Shore

Depth (meters)	20% Temp (°C)	20% D.O. (mg/l)	40% Temp (°C)	40% D.O. (mg/l)	50% Temp (°C)	50% D.O. (mg/l)	60% Temp (°C)	60% D.O. (mg/l)	80% Temp (°C)	80% D.O. (mg/l)
RM [illegible], September 7, 1979										
1	25.2	6.3	25.1	6.5	25.1	6.6	25.2	6.8	25.4	6.5
2	25.1	6.5	25.1	6.6	[illegible]	6.6	25.2	6.3	25.4	6.7
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9					[illegible]	[illegible]	[illegible]	[illegible]		
10					[illegible]	[illegible]	[illegible]	[illegible]		
11					[illegible]		[illegible]			
12										
RM [illegible], September [illegible], 1979										
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	6.7	[illegible]	[illegible]	[illegible]	6.6	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	6.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8							[illegible]	[illegible]	[illegible]	
9							[illegible]	[illegible]		
10										
11										
12										
13										

Relative Distance from Kentucky Shore

Depth (meters)	20% Temp (°C)	20% D.O. (mg/l)	40% Temp (°C)	40% D.O. (mg/l)	50% Temp (°C)	50% D.O. (mg/l)	60% Temp (°C)	60% D.O. (mg/l)	80% Temp (°C)	80% D.O. (mg/l)
RM [illegible], September [illegible], 1979										
1	[illegible]	6.7	25.7	6.6	25.5	6.7	25.3	6.5	25.6	6.7
2	25.6	6.7	25.7	6.6	25.4	6.7	25.3	6.7	25.6	6.7
3	25.5	6.7	25.7	6.5	25.5	6.7	25.5	6.7	25.6	6.7
4	25.5	6.6	25.6	6.8	25.6	6.7	25.5	6.7	25.6	6.7
5			25.6	6.9	25.6	6.6	25.5	6.7	25.6	6.7
6			25.6	[illegible]	25.5	6.7	25.5	6.7	25.6	6.8
7					25.4	6.8	25.5	6.7	25.6	6.8
8					25.4	6.8	25.4	6.7		
9					25.4	6.8	25.4	6.7		
10							25.3	6.7		
11										
12										
RM 715, September 7, 1979										
1	25.4	6.6	25.7	6.7	25.7	6.7	25.6	6.7	25.7	6.7
2	25.6	6.6	25.7	6.7	25.5	6.8	25.6	6.7	25.7	6.7
3	25.6	6.8	25.7	6.7	25.5	6.8	25.6	6.7	25.5	6.8
4			25.6	6.7	25.5	6.9	25.4	6.7	25.5	6.8
5			25.5	6.7	25.4	6.8	25.2	6.7		
6			25.5	6.7	25.4	6.8	25.2	6.8		
7			25.4	6.7	25.2	6.8	25.2	6.8		
8			25.4	6.8	25.2	6.9				
9			25.3	6.8	25.1	6.9				
10					25.1	6.9				
11										
12										
13										

Relative Distance from Kentucky Shore

Depth (meters)	20% Temp (°C)	20% D.O. (mg/l)	40% Temp (°C)	40% D.O. (mg/l)	50% Temp (°C)	50% D.O. (mg/l)	60% Temp (°C)	60% D.O. (mg/l)	80% Temp (°C)	80% D.O. (mg/l)
RM [illegible], September [illegible], 1979										
1	25.7	6.6	[illegible]	[illegible]	25.7	6.7	[illegible]	[illegible]	[illegible]	6.7
2	25.7	6.7	25.6	6.7	25.5	6.7	25.3	6.6	[illegible]	6.7
3	25.7	6.7	25.7	6.7	25.6	6.7	25.5	6.7	25.6	6.7
4	25.7	6.6	25.7	6.7	25.4	6.7	25.5	6.7	25.5	6.7
5			25.6	6.7	25.4	6.7	25.5	6.7	25.5	6.7
6			25.5	6.7	25.4	6.7	[illegible]	[illegible]	[illegible]	6.7
7			25.5	6.7	[illegible]	[illegible]	[illegible]	[illegible]		
8			25.4	6.7	[illegible]	6.7	[illegible]	[illegible]		
9					25.3	6.7	25.3	6.7		
10					25.3	6.8	[illegible]	6.7		
11					[illegible]	6.8				
12										
RM [illegible], September 6, 1979										
1	[illegible]	6.8	[illegible]	6.8	[illegible]	6.9	[illegible]	[illegible]	[illegible]	[illegible]
2	25.7	6.9	[illegible]	6.8	25.6	6.9	25.6	6.9	25.7	6.8
3	25.6	6.9	25.6	6.9	25.5	6.9	25.6	6.8	[illegible]	6.8
4	25.7	6.9	25.6	6.9	25.7	6.9	25.6	6.9	[illegible]	6.9
5			25.2	6.9	25.6	6.9	25.5	6.9	25.3	6.9
6			25.3	6.9	[illegible]	6.9	25.3	6.9		
7			25.1	6.9	[illegible]	6.9	25.1	7.0		
8			[illegible]	7.1	[illegible]	6.9	25.3	6.9		
9			25.1	[illegible]	25.2	6.9				
10					25.2	7.0				
11					25.1	[illegible]				
12										
13										
14										

Relative Distance from Kentucky Shore

Depth (meters)	20% Temp (°C)	20% D.O. (mg/l)	40% Temp (°C)	40% D.O. (mg/l)	50% Temp (°C)	50% D.O. (mg/l)	60% Temp (°C)	60% D.O. (mg/l)	80% Temp (°C)	80% D.O. (mg/l)
RM 705, April 30, 1980										
1	15.3	8.8	[illegible]	8.9	15.2	8.8	15.3	8.9	15.2	[illegible]
2	15.1	8.8	15.3	8.9	15.1	8.8	15.3	8.9	15.0	8.9
4	15.1	8.9	15.1	8.9	15.0	8.8	15.0	8.8	15.0	8.9
6			15.0	8.9	14.9	8.7	14.9	8.8		
8					14.5	8.7	14.9	8.8		
10					14.8	8.7	14.9	8.9		
12										
14										
16										
RM 707, April 30, 1980										
1	15.5	8.9	15.6	8.9	15.6	8.9	15.4	8.9	[illegible]	8.8
2	15.4	8.9	15.6	8.9	15.6	[illegible]	15.4	8.9	[illegible]	8.7
4			15.2	[illegible]	15.4	8.8	15.4	8.9	[illegible]	8.8
6			15.2	8.7	15.4	8.9	15.3	8.9		
8					15.2	9.0	15.3	8.8		
10					15.2	[illegible]				
12										
14										
16										

Relative Distance from Kentucky Shore

Depth (meters)	20% Temp (°C)	20% D.O. (mg/l)	40% Temp (°C)	40% D.O. (mg/l)	50% Temp (°C)	50% D.O. (mg/l)	60% Temp (°C)	60% D.O. (mg/l)	80% Temp (°C)	80% D.O. (mg/l)
RM 715, April 30, 1980										
1	[illegible]	8.9	15.4	8.9	15.5	8.9	15.6	8.9	15.5	[illegible]
2	15.2	8.8	15.4	8.9	15.5	8.9	15.7	8.9	15.4	8.8
4	15.2	8.9	15.7	8.8	[illegible]	8.7	[illegible]	[illegible]	[illegible]	[illegible]
6			15.3	[illegible]	15.3	8.8	[illegible]	8.7		
8					15.3	8.7				
10					15.1	8.7				
12					[illegible]	[illegible]				
14										
16										
RM 717, April 30, 1980										
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
6			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
8			[illegible]	[illegible]	[illegible]	[illegible]				
10			[illegible]	[illegible]	[illegible]	[illegible]				
12					[illegible]	[illegible]				
14					[illegible]	[illegible]				
16										

Relative Distance from Kentucky Shore

Depth (meters)	20% Temp (°C)	20% D.O. (mg/l)	40% Temp (°C)	40% D.O. (mg/l)	50% Temp (°C)	50% D.O. (mg/l)	60% Temp (°C)	60% D.O. (mg/l)	80% Temp (°C)	80% D.O. (mg/l)
RM 722, April 30, 1980										
1	15.6	9.3	15.7	9.0	15.8	9.1	15.8	8.8	15.8	9.1
2	15.6	8.9	15.7	8.9	15.5	8.8	15.6	8.7	15.8	[illegible]
4	15.6	8.9	15.6	8.8	15.6	8.8	15.6	8.7	15.6	8.8
6			14.6	8.8	15.6	8.8	[illegible]	8.7		
8					15.6	8.8	15.5	8.7		
10					15.5	8.8				
12					15.4	8.8				
14										
16										

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Table 3.4-7. Temperature and Dissolved Oxygen Profiles, Ohio River Miles 705, 707, 715, 717, and 722, 1979-1980 (Sheet 2 of 5)

Relative Distance from Kentucky Shore

	20%		40%		50%		60%		80%	
Depth (meters)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)
RM 715, August 7, 1979										
1	25.0	6.7	25.0	6.7	25.0	6.7	25.0	6.7	25.0	6.7
2	25.0	6.7	25.0	6.7	25.0	6.7	25.0	6.7	25.0	6.7
3	25.0	6.7	25.0	6.7	25.0	6.7	25.0	6.7	25.0	6.7
4	25.0	6.7	25.0	6.7	25.0	6.7	25.0	6.7	25.0	6.7
5	25.0	6.7	25.0	6.7	25.0	6.7	25.0	6.7		
6			25.0	6.7	25.0	6.7	24.9	6.6		
7			25.0	6.7	24.9	6.7	24.8	6.7		
8			25.0	6.7	24.8	6.7	24.8	6.7		
9					24.8	6.7	24.8	6.6		
10					24.5	6.6				
11										
RM 717, August 7, 1979										
1	24.9	6.6	24.8	6.6	24.8	6.5	24.8	6.6	25.0	6.6
2	24.9	6.6	24.8	6.6	24.8	6.5	24.8	6.6	25.0	6.6
3	24.9	6.6	24.8	6.6	24.8	6.5	24.8	6.6	25.0	6.6
4	24.9	6.6	24.8	6.6	24.8	6.5	24.8	6.6	25.0	6.6
5			24.8	6.6	24.7	6.5	24.8	6.6	24.9	6.5
6			24.8	6.6	24.7	6.5	24.8	6.6		
7			24.8	6.6	24.6	6.6				
8					24.5	6.6				
9					24.5	6.6				
10										
11										

Relative Distance from Kentucky Shore

	20%		40%		50%		60%		80%	
Depth (meters)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)
RM 722, August 7, 1979										
1	25.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	25.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	25.0	[illegible]	24.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	25.0	[illegible]	24.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	24.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7			[illegible]	[illegible]	24.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9					[illegible]	[illegible]	[illegible]	[illegible]		
10					[illegible]	[illegible]				
11					[illegible]	[illegible]				
RM 705, August 23, 1979										
1	25.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	25.2	6.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	25.2	[illegible]	25.3	6.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4			25.2	6.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5			25.0	6.4	25.0	6.3	25.2	6.3		
6			25.0	6.4	25.0	6.3	25.2	6.3		
7					25.0	6.4	25.1	6.4		
8					25.0	6.4	25.1	6.4		
9					25.0	6.4				
10					24.9	6.5				
11										
12										

Relative Distance from Kentucky Shore

	20%		40%		50%		60%		80%	
Depth (meters)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)
RM 707, August 23, 1979										
1	25.3	6.6	25.3	6.6	25.3	6.7	25.3	6.7	25.3	6.6
2	25.3	6.6	25.3	6.6	25.3	6.7	25.3	6.7	25.3	6.6
3	25.3	6.6	25.3	6.6	25.3	6.7	25.2	6.7	25.3	6.6
4	25.3	6.6	25.3	6.6	25.3	6.7	25.2	6.7	25.3	6.6
5			25.2	6.6	25.2	6.7	25.2	6.7	25.2	6.6
6			25.2	6.6	25.2	6.7	25.1	6.6		
7					25.2	6.6	25.1	6.6		
8					25.2	6.6	25.0	6.6		
9							25.0	6.6		
10							25.0	6.6		
11										
RM 715, August 23, 1979										
1	25.4	6.5	25.3	6.4	25.3	6.4	25.3	6.5	25.3	6.5
2	25.4	6.5	25.3	6.4	25.3	6.4	25.3	6.4	25.3	6.5
3	25.4	6.5	25.3	6.4	25.3	6.4	25.3	6.4	25.3	6.5
4			25.3	6.4	25.3	6.4	25.3	6.4	25.3	6.5
5			25.3	6.4	25.2	6.4	25.2	6.4	25.5	6.5
6			25.2	6.5	25.2	6.4	25.2	6.4		
7					25.2	6.4	25.2	6.4		
8					25.1	6.4	25.2	6.4		
9					25.1	6.4				
10					25.1	6.4				
11										
12										
13										

Relative Distance from Kentucky Shore

	20%		40%		50%		60%		80%	
Depth (meters)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)
RM 717, August 23, 1979										
1	25.2	6.6	25.4	6.6	25.4	6.6	25.3	6.7	25.3	6.7
2	25.2	6.6	25.4	6.6	25.4	6.6	25.3	6.7	25.3	6.7
3	25.2	6.6	25.4	6.6	25.4	6.6	25.3	6.7	25.3	6.7
4	25.2	6.6	25.4	6.6	25.2	6.5	25.3	6.7	25.2	6.7
5	25.2	6.6	25.1	6.6	25.2	6.5	25.3	6.8	25.2	6.7
6			25.1	6.6	25.2	6.6	25.1	6.9		
7			25.1	6.7	25.2	6.6	25.1	6.8		
8			25.1	6.7	25.2	6.6	25.0	6.8		
9					25.2	6.6	25.0	6.9		
10					25.0	6.7				
11										
RM 722, August 23, 1979										
1	25.4	6.7	25.4	[illegible]	25.3	6.7	25.3	6.7	25.3	6.5
2	25.4	6.7	25.4	[illegible]	25.3	6.7	25.3	6.7	25.3	6.5
3	25.4	6.7	25.4	[illegible]	25.3	6.7	25.3	6.7	25.3	6.5
4			25.4	[illegible]	25.3	6.7	25.3	6.7	25.3	6.5
5			25.2	[illegible]	25.3	6.7	25.2	6.7	25.1	6.7
6			25.2	[illegible]	25.2	6.7	25.2	6.7	25.1	6.7
7					25.1	6.7	25.2	6.7	25.0	6.7
8					25.0	6.8	25.2	6.7	25.0	6.7
9					25.0	6.8	25.1	6.8		
10					25.0	6.8	25.1	6.8		
11					25.0	6.8	25.1	6.8		
12					25.0	6.8				
13										

Relative Distance from Kentucky Shore

	20%		40%		50%		60%		80%	
Depth (meters)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)
RM 705, September 2, 1979										
1	25.4	6.8	25.4	6.8	25.3	6.6	25.3	6.8	25.3	6.7
2	25.4	6.8	25.4	6.8	25.3	6.7	25.3	6.8	25.3	6.7
3	25.4	6.8	25.4	6.8	25.3	6.7	25.3	6.8	25.3	6.7
4			25.4	6.8	25.3	6.7	25.3	6.8	25.2	6.7
5			25.2	6.8	25.3	6.7	25.2	6.8	25.1	6.7
6			25.0	6.8	25.3	6.7	25.2	6.8	25.1	6.7
7			25.0	6.9	25.3	6.7	25.0	6.8		
8					25.2	[illegible]	25.0	6.8		
9					25.0	6.8	25.0	6.8		
10					25.0	6.9				
11					25.0	6.9				
12										
13										
RM 707, September 2, 1979										
1	25.5	[illegible]	25.5	6.7	25.4	[illegible]	25.4	6.7	25.4	6.7
2	25.5	6.8	25.5	6.7	25.4	6.7	25.4	6.7	25.4	6.7
3	25.5	6.8	25.5	6.7	25.4	6.7	25.4	6.7	25.3	6.7
4	25.5	6.8	25.3	6.7	25.4	6.7	25.4	6.7	25.2	6.7
5			25.3	6.7	25.4	6.7	25.4	6.7	25.2	6.7
6			25.2	6.7	25.4	6.7	25.4	6.7	25.0	6.7
7			25.2	6.8	25.3	6.7	25.4	6.8		
8					25.3	6.8	25.4	6.8		
9					25.2	6.8	25.2	6.8		
10					25.2	6.9	25.2	6.8		
11					25.1	6.9				
12										
13										

Relative Distance from Kentucky Shore

	20%		40%		50%		60%		80%	
Depth (meters)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)	Temp (°C)	D.O. (mg/l)
RM 715, September 2, 1979										
1	25.4	6.6	25.4	6.6	25.5	6.6	25.5	6.7	25.5	6.6
2	25.4	6.6	25.4	6.6	25.5	6.6	25.5	6.7	25.5	6.6
3	25.4	6.6	25.4	6.6	25.5	6.6	25.5	6.7	25.5	6.6
4			25.4	6.6	25.5	6.6	25.4	6.7	25.3	6.6
5			25.4	6.6	25.5	6.6	25.4	6.7	25.2	6.6
6			25.4	6.6	25.3	6.7	25.4	6.8	25.2	6.7
7					25.3	6.7	25.2	6.8	25.2	6.7
8					25.2	6.7	25.2	6.8		
9					25.2	6.7	25.2	6.8		
10							25.0	6.8		
11										
12										
13										
RM 717, September 2, 1979										
1	25.5	6.8	25.4	6.7	25.4	6.7	25.4	6.7	25.4	6.7
2	25.5	6.8	25.4	6.6	25.4	6.7	25.4	6.7	25.4	6.7
3	25.5	6.8	25.2	6.6	25.4	6.7	25.4	6.7	25.4	6.7
4	25.5	6.8	25.2	6.6	25.4	6.7	25.4	6.7	25.2	6.7
5			25.2	6.7	25.4	6.7	25.4	6.7	25.2	6.8
6			25.2	6.7	25.3	6.7	25.4	6.7	25.2	6.8
7			25.2	6.7	25.2	6.8	25.4	6.7		
8			25.2	6.7	25.2	6.8	25.4	6.7		
9					25.0	6.9	25.2	6.7		
10					25.0	6.6	25.2	6.7		
11					25.0	6.9	25.0	6.7		
12							25.0	6.7		
13										

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3.4.1.1.4.2 Heavy Metals in Fish Tissue, Ohio River Miles 702 to 722

Fish tissue analyzed for heavy metals concentrations included gills, liver, and muscle of largemouth bass and river carpsucker; muscle and gills of walleye, channel catfish, and carp; and whole bodies of young-of-the-year largemouth bass (Table 3.4-8). Edible muscle of all species appeared to have elevated concentrations of arsenic and selenium. Daily average ingestion of arsenic by man is 0.9 milligrams (mg) (Schroeder and Balassa 1966). Ingestion of 1 kilogram (kg) (2.2 pounds) per day of walleye or channel catfish having levels of arsenic listed in Table 3.4-8 would not exceed 0.9 mg per day but ingestion of 1 kg per day of largemouth bass would exceed the average. It is doubtful that local residents consume such a steady diet of fish from the river. Further, arsenic generally is not concentrated along a food chain, and organically bound arsenic has a low toxicity (Ferguson and Gavis 1972).

Selenium levels required and normally ingested by man vary from 0.04 to 0.1 mg per day. Greater amounts have produced signs of selenium toxicity (EPA 1976). Ingestion of 25 mg (dry weight) per day of a combined average concentration of 4.7 mg/kg (dry weight muscle from walleye, largemouth bass, and catfish) would produce ingestion levels greater than 0.1 mg of selenium per day.

Concentrations of mercury, which is the only metal regulated by the U.S. Food and Drug Administration, slightly exceeded the 1 mg/kg standard in largemouth bass. All other fish tissues showed levels at or near the 0.02 mg/kg lower limit of detectability.

Although concentrations of most metals were not elevated, the tendency for bioaccumulation of many is indicated by increased levels in fish higher in the food chain (largemouth bass, walleye, channel catfish). Bioaccumulation is further illustrated by the low levels of most metals in the young-of-the-year largemouth bass.

3.4.1.2 Groundwater

The groundwater system in the Ohio Basin generally is directly connected to the stream system and is the source of the natural low flows (ORBC 1978). Moderate to plentiful groundwater supplies are available throughout most of the glacial till areas and in the alluvial valleys of other portions of the Basin. Both the Hancock and Breckinridge sites are in locations generally considered to have highest potential yield - a minimum of 100 to 300 gallons per minute (gpm) per well. Most of the remainder of Hancock County and the northern one-half of Breckinridge County are in locations of intermediate yield - minimum of 20 to 100 gpm per well. Wells in the Ohio River alluvium can yield more than 1000 gpm. The southern parts of Breckinridge County and Hardin County, where the Elizabethtown transmission corridor is partially located, are areas in the Basin of lowest potential yield - less than 20 gpm per well.

3.4.1.2.1 Aquifer Characteristics

The alluvium of the Ohio River floodplain contains the greatest potential source of groundwater in the project area, with the water-bearing sandstones and limestones of the uplands a secondary source (Maxwell and Devaul 1962). The texture of the alluvium varies from clays and silt to mixtures of

Table 3.4-8. Heavy Metals (mg/kg Dry Weight) Concentrations in Fish Tissues, Ohio River Miles 702-722, 1979-1980

Fish Tissue*	Iron (Fe)	Zinc (Zn)	Nickel (Ni)	Lead (Pb)	Arsenic (As)	Silver (Ag)	Selenium (Se)	Cadmium (Cd)	Chromium (Cr)	Barium (Ba)	Manganese (Mn)	Copper (Cu)	Mercury (Hg)
Walleye													
Muscle	4.9	3.7	1.3	< 0.10	1.4	0.17	4.3	0.03	0.03	0.57	0.20	0.66	<0.02
Gills	126	20.7	2.0	0.11	0.4	<0.03	2.9	0.26	0.15	2.59	6.70	2.11	<0.02
Largemouth bass													
Muscle	5.1	13.0	0.70	0.48	2.2	0.24	6.6	0.46	0.65	<0.02	0.85	1.76	1.16
Liver	24.2	97.7	1.86	0.81	3.0	1.16	6.1	6.40	2.21	0.12	13.70	8.72	2.44
Gills	42.2	80.2	1.23	1.98	2.2	<0.5	22.8	4.81	1.98	0.09	20.30	4.25	0.36
Whole**	2.0	6.5	1.70	<0.10	0.4	<0.03	<0.3	0.03	0.26	<0.30	<0.03	1.09	<0.02
Channel catfish													
Muscle	6.3	4.8	1.10	<0.10	1.0	<0.03	3.3	0.15	0.09	0.57	0.20	0.66	<0.02
Gills	58.0	10.8	1.80	<0.10	0.6	<0.04	2.9	0.21	0.17	2.07	6.60	0.79	<0.02
Carp													
Muscle	7.2	1.2	1.10	<0.10	1.3	<0.03	3.3	0.15	<0.03	<0.30	0.12	0.78	<0.02
Gills	241	314.0	2.10	<0.10	0.8	<0.03	0.8	0.22	0.30	3.58	22.30	1.16	<0.02
River carpsucker													
Muscle	2.9	2.5	1.2	<0.10	2.3	<0.04	2.9	0.17	0.04	<0.40	0.50	2.17	<0.02
Liver	523	33.4	1.2	<0.10	1.2	0.21	0.4	2.80	0.56	1.05	0.52	34.00	0.08
Gills	261	20.3	2.3	2.10	0.8	<0.03	1.5	0.72	0.53	3.13	22.30	1.38	<0.02

---

*Each tissue is a composite from 3 to 5 fish.

**Represents a group of young-of-the-year.

Source: Texas Instruments Incorporated field data (1979-1980).

sand and gravel. A coarse basal layer of sand or sand and gravel is present along most of the valley. The clays influence the flow of water to other formations but are insignificant as aquifers in comparison to the coarse deposits. Thickness of the valley alluvium increases toward the river, because of the slope of the bedrock surface, and is greatest (up to 150 feet) in the ancient bedrock channel of the river. Thinnest alluvium is near the valley wall and over buried bedrock ridges.

The extent of the alluvial plain also varies (Devaul and Maxwell 1962; Brown and Lambert 1963). In the project area, the Ohio Valley ranges in width from less than 1000 feet at Hawesville and areas upstream in Hancock and Breckinridge counties to 2 miles at the confluence of Blackford Creek downstram of Hawesville in Hancock County. Alluvium of the streams on the Hancock and Breckinridge sites, like that of other tributaries, is much thinner than the Valley alluvium, although often relatively extensive as in the case of Town Creek on the Breckinridge site. Because of the thinness, tributary alluvium is not considered an important groundwater source. Examples of yields from the Valley alluvium in the study area are 350 gpm from several 93-foot deep public-supply wells at Hawesville to 300 gpm from several 84-foot deep municipal wells at Lewisport, downstream of Hawesville (Gallaher and Price 1966). The generalized groundwater availability in Hancock County (which was studied along with other counties in the Western Coal Field) is shown in Figure 3.4-5.

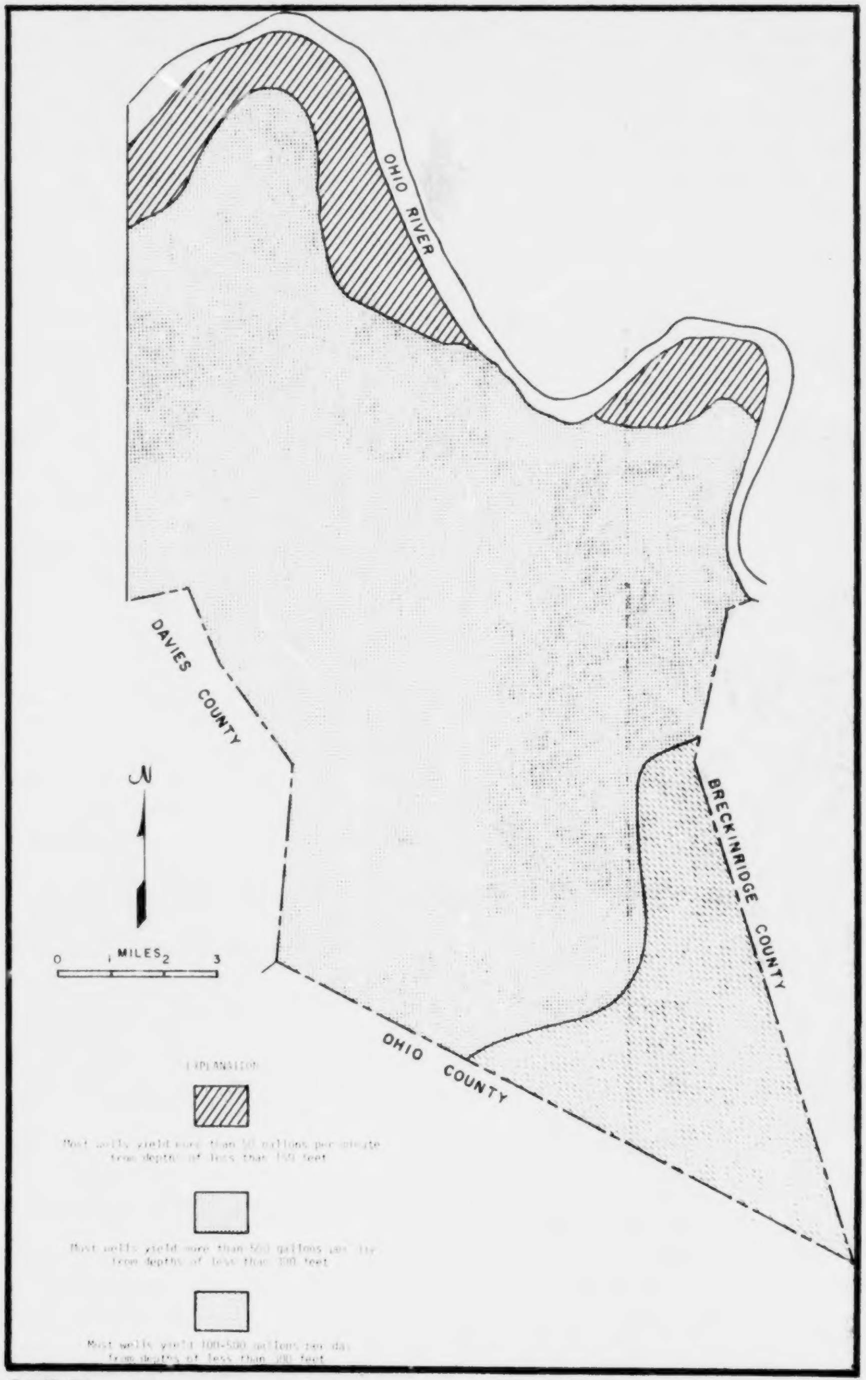
The bedrock aquifers of sandstone and limestone formations, as mentioned, have less groundwater potential generally than the alluvial deposits. The study area is in the Illinois Basin seismotectonic region (Subsection 3.3.1.2.1) where bedrock generally is deeper and aquifers more productive than in upstream areas that are in the Cincinnati Arch. The dip of bedrock in the study area generally is to the west, at the rate of 25 feet per mile.

Studies of Hancock County groundwater indicate that the Caseyville Sandstone (Subsection 3.3.1.1.4) probably is the most important bedrock aquifer in the county, with limestone formations second (McGrain et al. 1970). Neither shale nor siltstone is productive in the project area or in the Ohio River Basin in general. Some wells in sandstone formations can yield up to 500 gpm at depths down to 300 feet, although average yield is much less (approximately 100 gpm). Limestone aquifers generally yield an average of 20 gpm, while shale formations and thin sandstone generally yield only 100 to 500 gallons per day.

3.4.1.2.2 Groundwater Recharge

Groundwater reserves along the Ohio River floodplain are recharged from precipitation, leakage from permeable rocks at the valley wall adjacent to sand and gravel deposits, and streambed and bank infiltration from the river (Bell 1962). The contribution from precipitation is estimated to range from 0.3 mgd to 0.5 mgd per square mile (Whitesides and Ryder 1969). Less than 0.2 mgd per square mile of aquifer is attributed to leakage along the valley wall. Contribution from precipitation can be limited to construction of towns and roadways (pavements), as well as by high silt and clay soils.

The predominate recharge is from the Ohio River. The hydraulic connection between the river and the alluvium aquifer ranges from poor to excellent depending on the thickness of silt and clays along the river bottom. Where the hydraulic connection is good, the aquifer gains seasonal recharge


OHIO RIVER
DAVIES COUNTY
BRECKINRIDGE COUNTY
OHIO COUNTY
N
0 1 MILES 2 3
EXPLANATION
Most wells yield more than 50 gallons per minute from depths of less than 150 feet
Most wells yield more than 500 gallons per day from depths of less than 300 feet
Most wells yield 100-500 gallons per day from depths of less than 300 feet

SOURCE: McGrain, P., H.R. Schwalb, and G.E. Smith. 1970. Economic geology of Hancock County, Kentucky. Kentucky Geological Survey County Report 4.

Figure 3.4-5. Generalized Groundwater Availability Map, Hancock County, Kentucky, 1970

during flood stages of the Ohio River. During flood stage, the groundwater flow gradient may be temporarily reversed, particularly near the edge of the river. High capacity water wells, yielding 1,000 gpm or more, are often placed as close to the river as possible where the hydraulic connection is good. The high yield of such wells is possible where induced stream bed infiltration can be utilized to prevent overpumpage from the aquifer.

Because the major source of groundwater in the area is the alluvium aquifer and recharge is predominantly from the regulated Ohio River, groundwater supplies probably exceed withdrawal. Existing pumpage records for Hancock and Breckinridge counties are shown in Table 3.4-9. With its manufacturing facilities, Hancock County is by far the greater consumer, with 26.09 mgd known pumpage vs. 0.346 mgd known pumpage for Breckinridge County.

3.4.1.2.3 Groundwater Quality

Groundwater quality in the project area is generally good. Water in the sandstone aquifers is soft to moderately hard but it may contain undesirable amounts of iron. Water from the alluvium aquifer generally is harder and contains more iron than the sandstone aquifers.

Several of the domestic and municipal wells in the project area exhibit higher to much higher iron levels than recommended by EPA (1976) for municipal systems. Wells supplying Cannelton, Indiana exhibit high levels of iron as well as levels of nitrates that exceed EPA's 10 mg per liter standard. With the exception of these chemicals, no pollution problems are associated with the project area groundwater. The iron, as indicated, is naturally occurring in the sandstone hemitites. Elevated nitrates may be due to leachates from agricultural fertilizers (Food and Agriculture Organization of the United Nations 1979).

3.4.1.3 Aquatic Biota

During the Hancock Generating station EIS program (see Section 5.0), aquatic biota were surveyed on the Hancock and Breckinridge sites and adjacent portions of the Ohio River. Sampling was conducted in the Ohio River from RM 702 to 722 and in four onsite streams - Indian Creek, Muddy Branch and Sandy Branch of the Hancock site (see Figure 3.1-6) and Town Creek on the Breckinridge site (see Figure 3.1-7). The onsite streams are typical of the area: they begin in sandstone and limestone of the upland forest areas and become sandy/silty-bottomed as they wind through the agricultural alluvium to the Ohio River.

In the Ohio River, the aquatic flora are typical of a mid-America large river that has high turbidity, silty/sandy substrate, and partial impounding (Hynes 1970). Alterations to the faunal components have occurred as a result of lock and dam construction, dredging, and industrial and domestic pollution. Many pollution-sensitive organisms have been eliminated from the river, leaving a majority of pollution-tolerant and facultative species.

3.4.1.3.1 Fish

Fish samples collected during the 1979-1980 study of Ohio River miles 702 to 708 and 715 to 722 yielded 32 of the 44 species reported from the

Table 3.4-9. Breckinridge and Hancock County Water Withdrawal Permits

Permit Number	County	Source	Permit Holder	Location		Million Gallons/Day			Number of Wells	Depth (feet)	Diameter (inches)
				N. Latitude	W. Longitude	Permitted	Actual	Year			
207	Breckinridge	Surface	City of Hardinsburg	37°47'23"	86°28'04"	0.130	0.220	1977	—	—	—
636	Breckinridge	Ground	City of Hardinsburg	37°50'10"	86°37'55"	0.091	0.078	1977	3	65	—
675	Breckinridge	Ground	Mago Construction	37°53'38"	86°18'15"	0.030	0.013	1977	1	135	8
712	Breckinridge	Ground	City of Irvington	37°53'02"	86°17'09"	0.095	0.119	1977	1	175	8
			Total			0.346					
120	Hancock	Ground	City of Hawesville	37°54'06"	86°44'48"	0.070	0.493	1976	2	93	4
492	Hancock	Ground	City of Lewisport	37°56'13"	86°53'59"	0.085	0.133	1977	1	84	14
589	Hancock	Ground	Martin Marietta	37°53'44"	86°46'11"	6.500	6.539	1968	6	90	24
597	Hancock	Ground	Willamette Ind.	37°53'44"	86°41'26"	2.330	3.471	1970	5	104-122	8-20
602	Hancock	Surface	Hancock Co. Ready Mix	37°55'34"	86°48'15"	0.005	0.004	1968	—	—	—
653	Hancock	Ground	National-Southwire	37°56'36"	86°47'10"	2.050	0.713	1973	5	135	6
729	Hancock	Ground	National Aluminium	37°56'13"	86°46'56"	7.200	6.492	1974	6	109	16
737	Hancock	Ground	Western Kraft Group	37°53'50"	86°40'40"	7.500	6.874	1974	5	105-142	8-24
742	Hancock	Ground	Kentucky Hills Dev.	37°55'27"	86°47'47"	0.350	0.035	1977	1	110	12
			Total			26.09					

Source: **Kentucky Department for Natural Resources and Environmental Protection, Water Resources Division (1979).**

Cannelton Lock and Dam at RM 721 (Table 3.4-10). A predominance of forage and rough fish was collected, with game and comemrcial fish taken in low numbers. The survey also yielded 6 species not previously reported from the Cannelton Lock and Dam: the stoneroller, mimic shiner, bullhead minnow, pumpkinseed sunfish, johnny darter, and log perch. These species are generally distributed in the Ohio River drainage and are likely inhabitants of the area, although some are rare. Although no Federally threatened or endangered species were collected during the study, three species on the Kentucky Nature Preserves Commission Animal Element List were collected in low numbers: the paddlefish (larvae), river shiner, and pirate perch (adults).

Figures 3.4-6, 3.4-7, and 3.4-8 show the numbers of fish collected in the project area by sampling method, sampling period, and location.

3.4.1.3.2 Shellfish

During the aquatic biota study, extensive surveys were made for mussels along the Kentucky shore of the Ohio River. No mussel beds were located and no individual mussels were collected, although a more recent survey has located a small aggregation of live mussels along the Kentucky shore near RM 708 (Dames and Moore, Personal Communication 1980). Historic mussel beds on the Indiana shore also were examined, with only shells recovered. These investigations indicate that earlier discharge of untreated industrial and municipal wastes and later lock and dam construction and water impoundment have severely decreased mussel populations in the area.

An extensive mussel fishery existed during the 1920s and 1930s in many major American rivers including the Ohio (Williams 1969). During World War II, a shortage of labor, a shortage of gasoline for outboard motors, a general depletion of mussel beds, and the widespread use of plastics for buttons greatly reduced most mussel fisheries. They were revived in the 1950s when the Japanese discovered that ground mussel shell pellets made excellent nuclei for cultured pearls. Since then, however, severe overfishing, coupled with lock-and-dam construction during the 1960s and 1970s has resulted in extreme depletion of mussel beds.

In 1967, an extensive mussel fishery worked by six musselmen existed in the vicinity of the project area (Williams 1969), but there is no such fishery today. The mussels of commercial importance in the area were the maple leaf, the monkey face, the ebony shell, the three ridge, the washboard, and *Pleurobema* spp.

3.4.1.3.3 Macroplankton and Macrobenthos

Fish Eggs and Larvae. Fish eggs and larvae collections at RM 705, 707, 715, 717, and 722 showed that greatest overall densities apparently occur during June in this section of the Ohio (Figure 3.4-9). Greatest taxonomic variety also occurs at this time. The most abundant larval fish collected during June (more than 50% of the total) were members of the herring/shad family. Peak density was found in samples collected during the third week in June, when 2,307 fish were collected per 100 m^3 sampled (Figure 3.4-9).

Taxa that were present in large numbers during one or more months of the study included members of the herring/shad family, the freshwater drum,

Table 3.4-10. Fish Collected at the Cannelton Lock and Dam (RM 721), 1968-1970 and 1975-1976, and from the Project Area (RM 702-722), 1979-1980

Common Name	Scientific Name	Time Span*
Paddlefish	Polyodon spathula	X, 0**
Longnose gar	Lepisosteus osseus	X, 0
Bowfin	Amia calva	X
American eel	Anguilla rostrata	X
Skipjack herring	Alosa chrysochioris	X, 0
Gizzard shad	Dorosoma cepedianum	X, 0
Threadfin shad	Dorosoma petenense	X
Goldeye	Hiodon alosoides	X, 0
Mooneye	Hiodon terigsus	X, 0
Goldfish	Carassius auratus	X, 0
Carp	Cyprinus carpio	X, 0
Stoneroller	Campostoma anomalum	0
Silver chub	Hybopsis storeriana	X
Golden shiner	Notemigonus crysoleucas	X, 0
Emerald shiner	Notropis atherinoides	X, 0
River shiner	Notropis blennius	X, 0**
Mimic shiner	Nortopis volucellus	0
River carpsucker	Carpiodes carpio	X
Quillback	Carpiodes cyprinus	X
Highfin carpsucker	Carpiodes velifer	X
Bullhead minnow	Pimephales vigilax	0
Smallmouth buffalo	Ictiobus bubalus	X
Bigmouth buffalo	Ictiobus cyprinellus	X
Spotted sucker	Minytrema melanops	X
Golden redhorse	Moxostoma erythrurum	X, 0
Blue catfish	Ictalurus furcatus	X
Black bullhead	Ictalurus melas	X
Yellow bullhead	Ictalurus natalis	X
Brown bullhead	Ictalurus nebulosus	X
Channel catfish	Ictalurus punctatus	X, 0
Flathead catfish	Pylodictis olivaris	X, 0
Pirate perch	Aphredoderus sayanus	X**,***
White bass	Morone chrysops	X, 0
Striped bass	Morone saxatilis	X
Green sunfish	Lepomis cyanellus	X, 0
Pumpkinseed	Lepomis gibbosus	0
Warmouth	Lepomis gulosus	X, 0
Bluegill	Lepomis macrochirus	X, 0
Longear sunfish	Lepomis megalotis	X, 0
Redear sunfish	Lepomis microlophus	X
Smallmouth bass	Micropterus dolomieui	X, 0
Spotted bass	Micropterus punctulatus	X
Largemouth bass	Micropterus salmoides	X, 0
White crappie	Pomoxis annularis	X, 0
Black crappie	Pomoxis nigromaculatus	X, 0
Johnny darter	Etheostoma nigrum	0
Log perch	Percina caprodes	0
Sauger	Stizostedion canadense	X, 0
Walleye	Stizostedion vitreum	X, 0
Freshwater drum	Aplodinotus grunniens	X, 0

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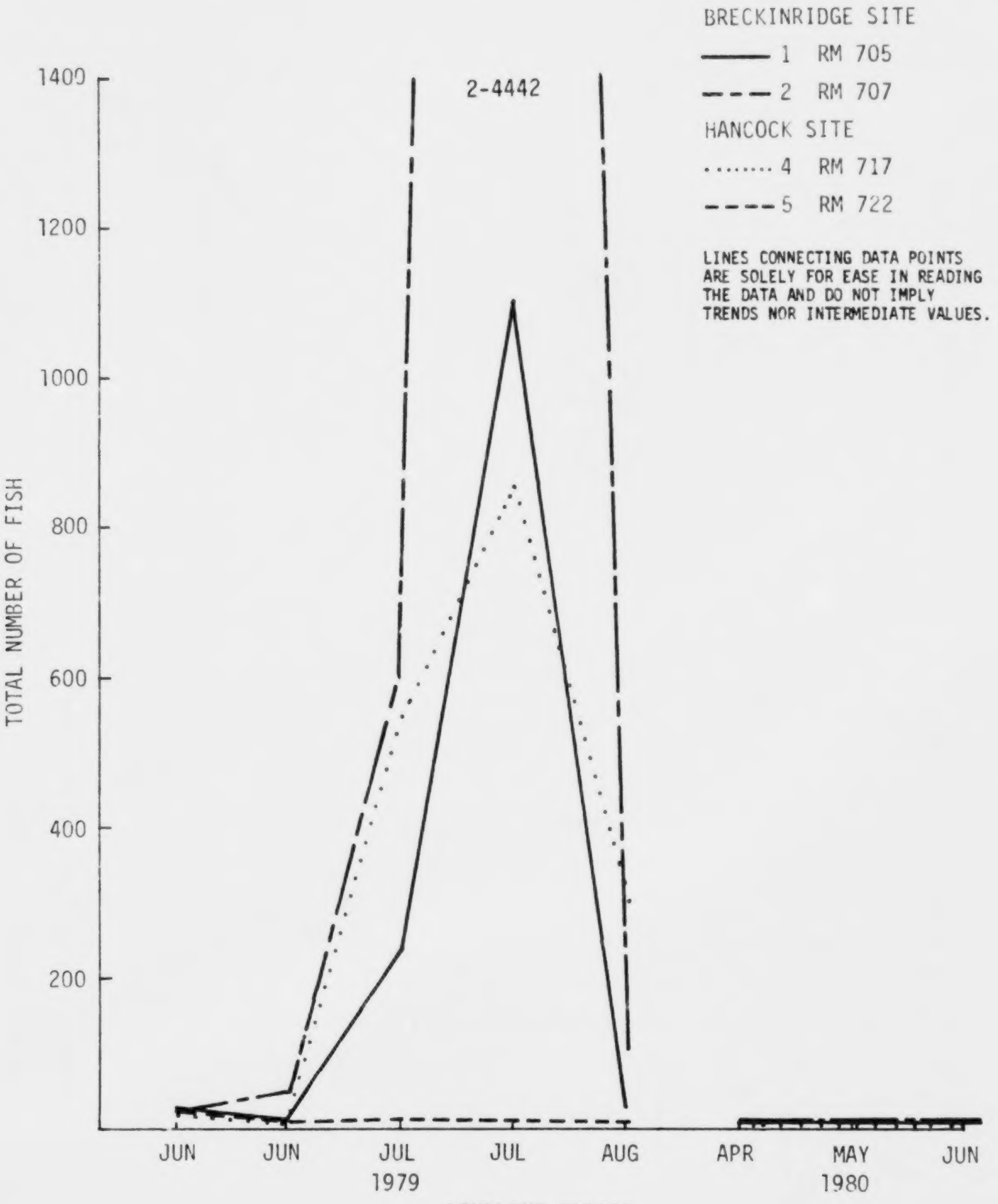
*X - collected during 1968-1970, 1975-1976 (Preston and White 1978).
0 - collected during 1979-1980 (Texas Instruments Incorporated).

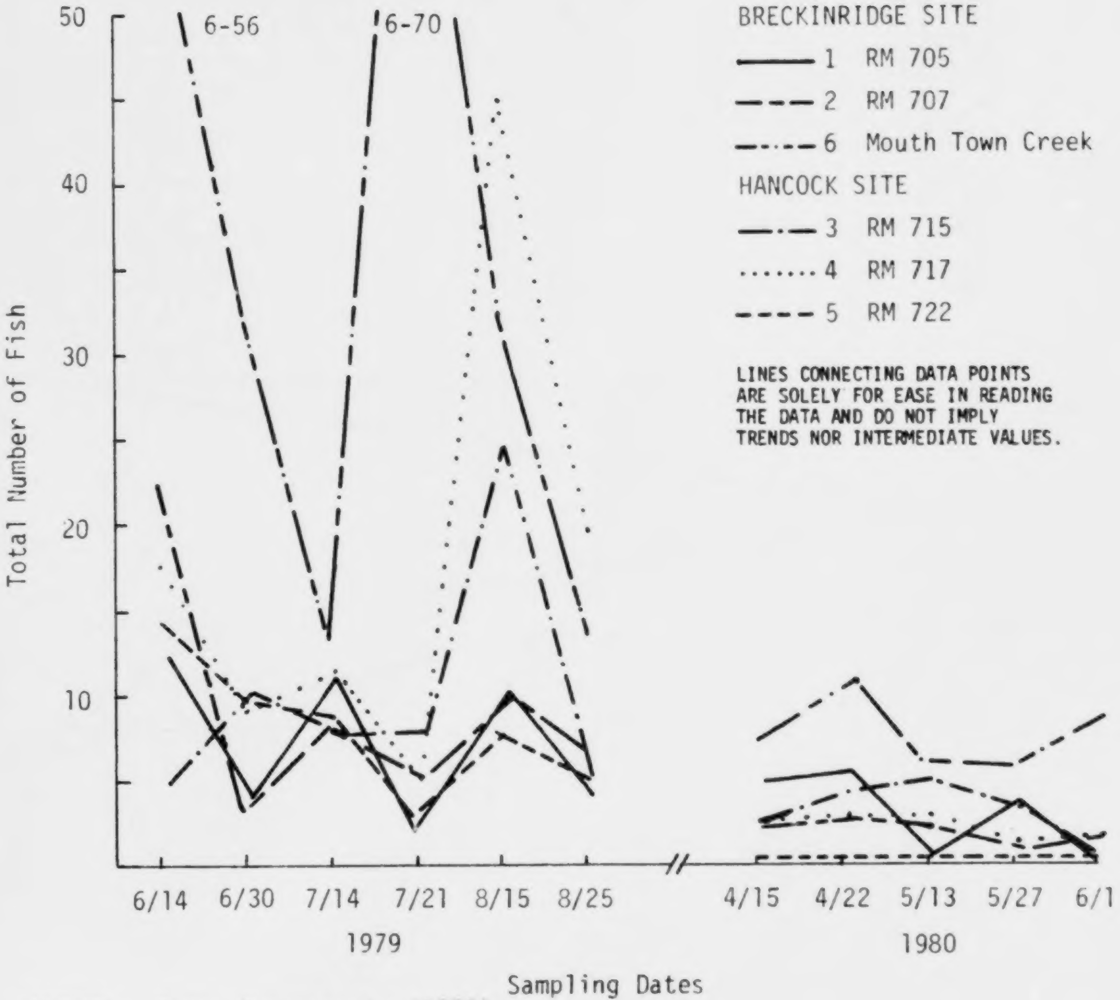
**Included in the Kentucky Nature Preserves Commission Animal and Plant Element List.

***Collected during 1979-1980 from on-site streams.



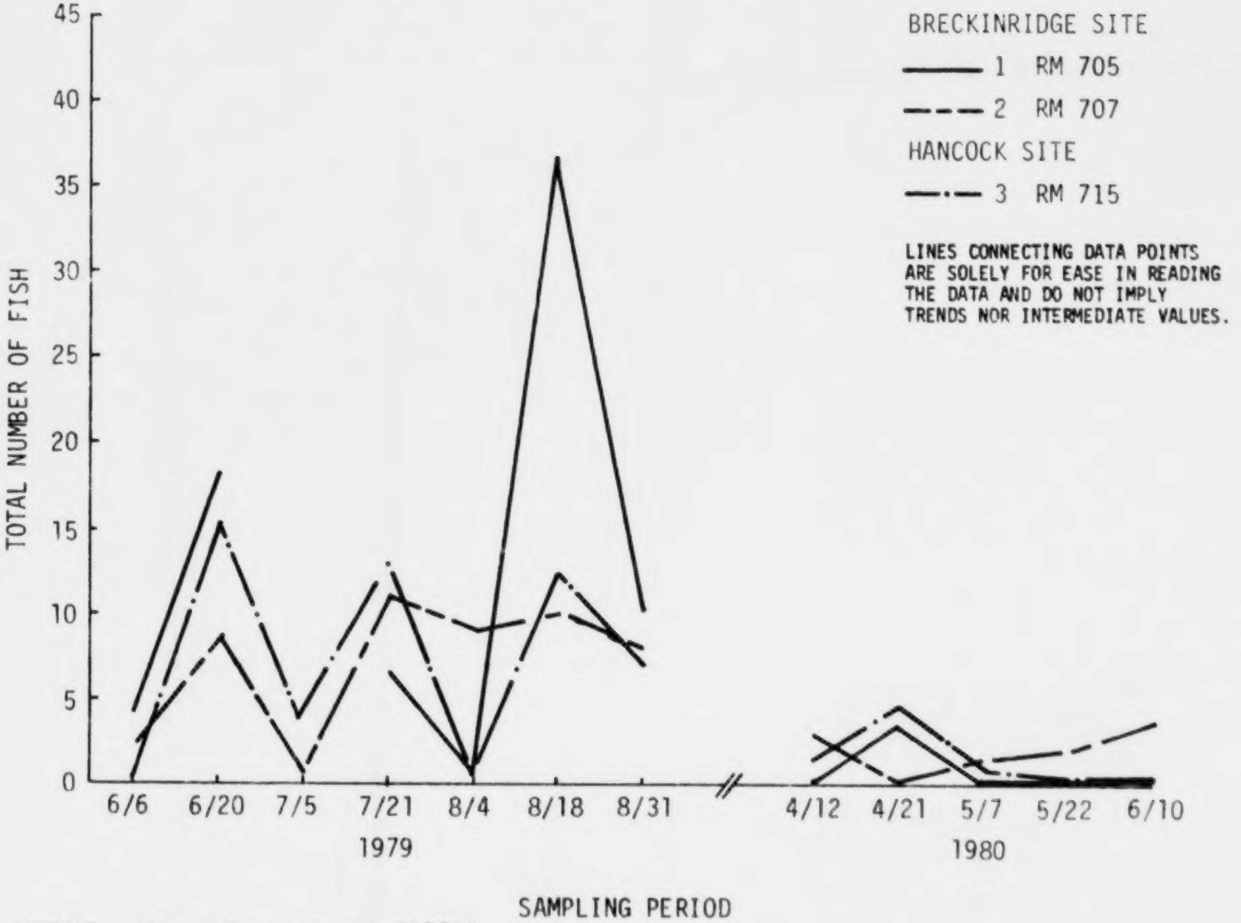
SOURCE: Texas Instruments (1980)

Figure 3.4-6. Numbers of Seined Fish, Ohio River Miles 705, 707, 717, and 722, 1979-1980



SOURCE: Texas Instruments (1980)

Figure 3.4-7. Numbers of Electrofished Fish, Ohio River Miles 705, 707, Mouth of Town Creek, 715, 717, and 722, 1979-1980



SOURCE: Texas Instruments (1980)

Figure 3.4-8. Numbers of Gillnetted Fish, Ohio River Miles 705, 707, and 715

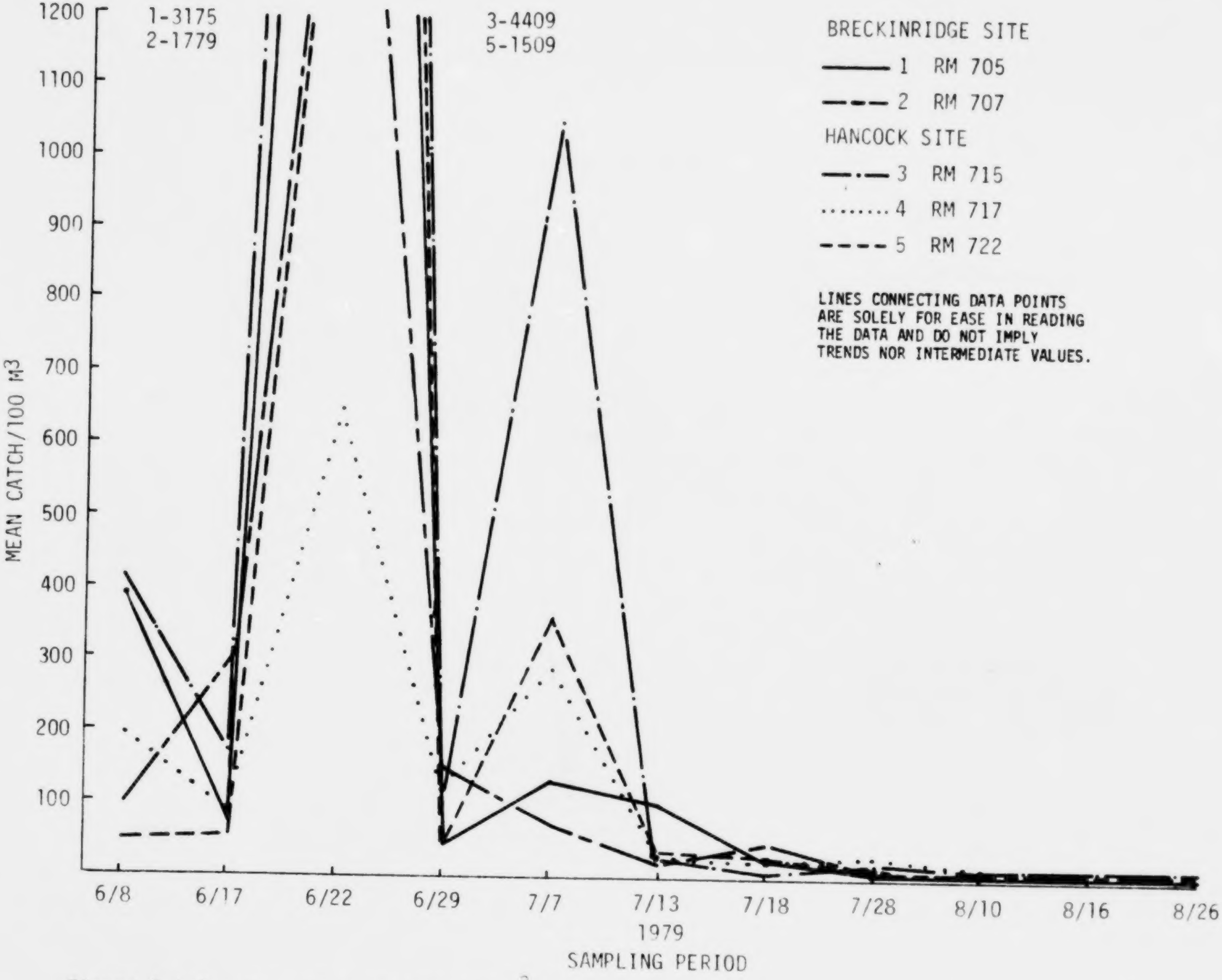
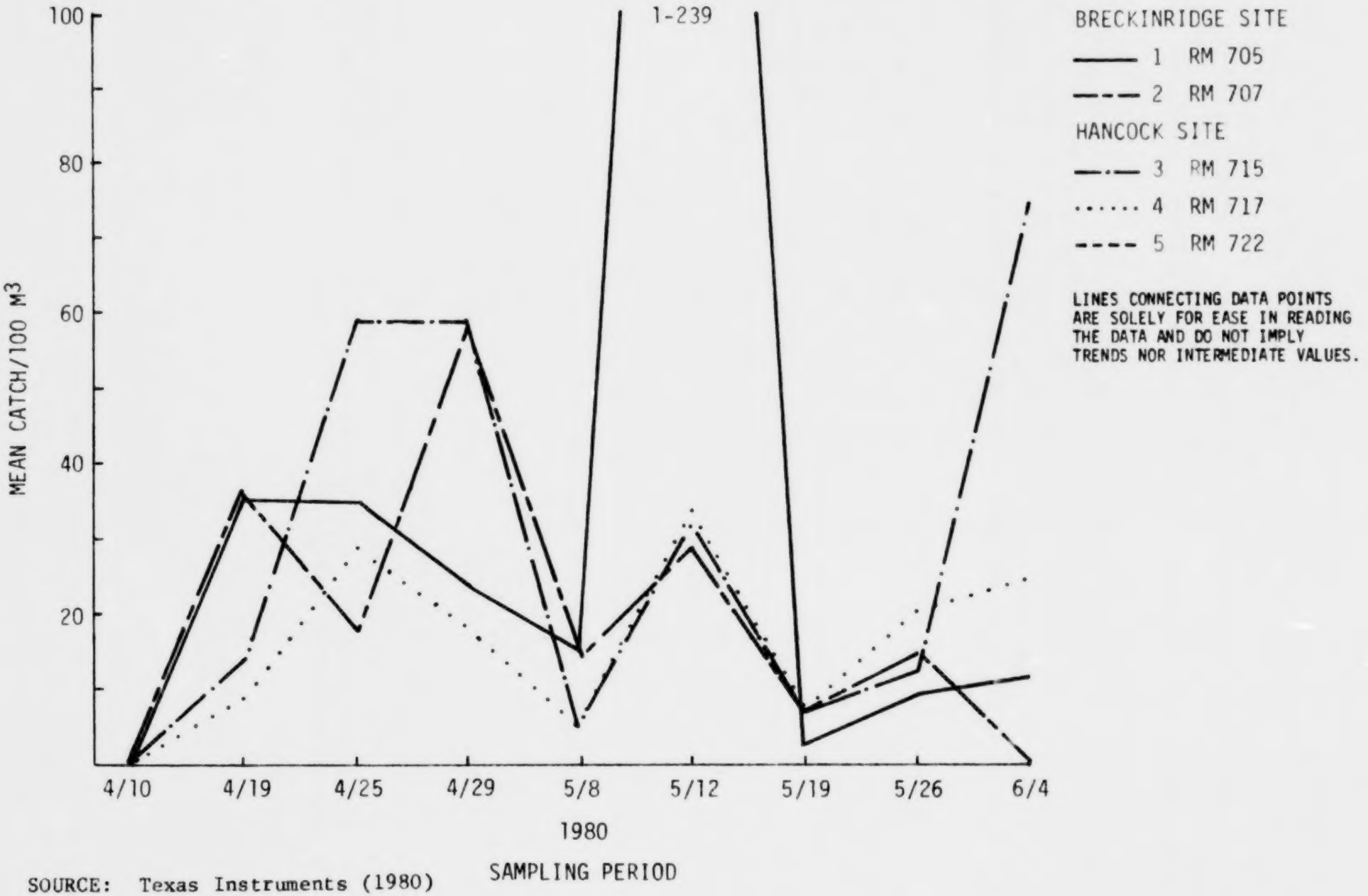


Figure 3.4-9. Mean Numbers (per 100 m^3) of Fish Eggs and Larvae, Ohio River Miles 705,707, 715,717, and 722, 1979-1980 (Sheet 1 of 2)



SOURCE: Texas Instruments (1980)

Figure 3.4-9. Mean Numbers (per 100 m^3) of Fish Eggs and Larvae, Ohio River Miles 705, 707, 715, 717, and 722, 1979-1980 (Sheet 2 of 2)

suckers, the carp, and the emerald shiner. As in the case of adults, forage fish were most often collected and game fish were comparatively few. Miscellaneous species (e.g., paddlefish collected during April 1980 at RM 707 and 717) also were comparatively few. Most of the 21 kinds of fish larvae and 4 kinds of eggs collected were represented in the adult catches. Distribution of the fish larvae was not always uniform across the river nor with depth, but no consistent trends were observed (transect data on file at EPA Region IV).

Macrozooplankton. Macrozooplankton analysis of one set of fish eggs and larvae samples per sampling month revealed maximum and second greatest densities of this plankton component in June and August, respectively (Figure 3.4-10). The greatest number of the 69 taxa collected was present in June. Occurrence of the maximum macrozooplankton density and diversity with that of larval fish is most important because larval fish feed exclusively on zooplankton.

The most diverse macroplankton group in this area of the Ohio River appears to be water fleas (Cladocera). Water fleas probably are consistently the dominant macrozooplankton group, although copepods (Copepoda) and naidid worms (Oligochaeta) were more abundant in April and May samples, respectively. Many copepods, like cladocerans, are inhabitants of the water column, while oligochaetes inhabit substrate and/or aquatic vegetation most consistently. Tubificid worms, which were abundant in the June macrozooplankton sample, especially are bottom dwellers and generally occur at greater depths than naidid worms. Their abundance in the macrozooplankton sample could have resulted from dragging the bottom-towed plankton net across the river bottom.

Except for the occurrences of oligochaetes, macrozooplankton distribution was generally similar across the length and depth of each sampling station.

Macrobenthos. Ponar dredge collections between RM 705-722 in the Ohio River contained 31 taxa. Greatest abundance of these bottom dwellers occurred during winter and spring (Figure 3.4-11). Densities of most organisms except tubificid worms and midges (Chironomidae) were relatively low. The greatest numbers of taxa also occurred during December and April.

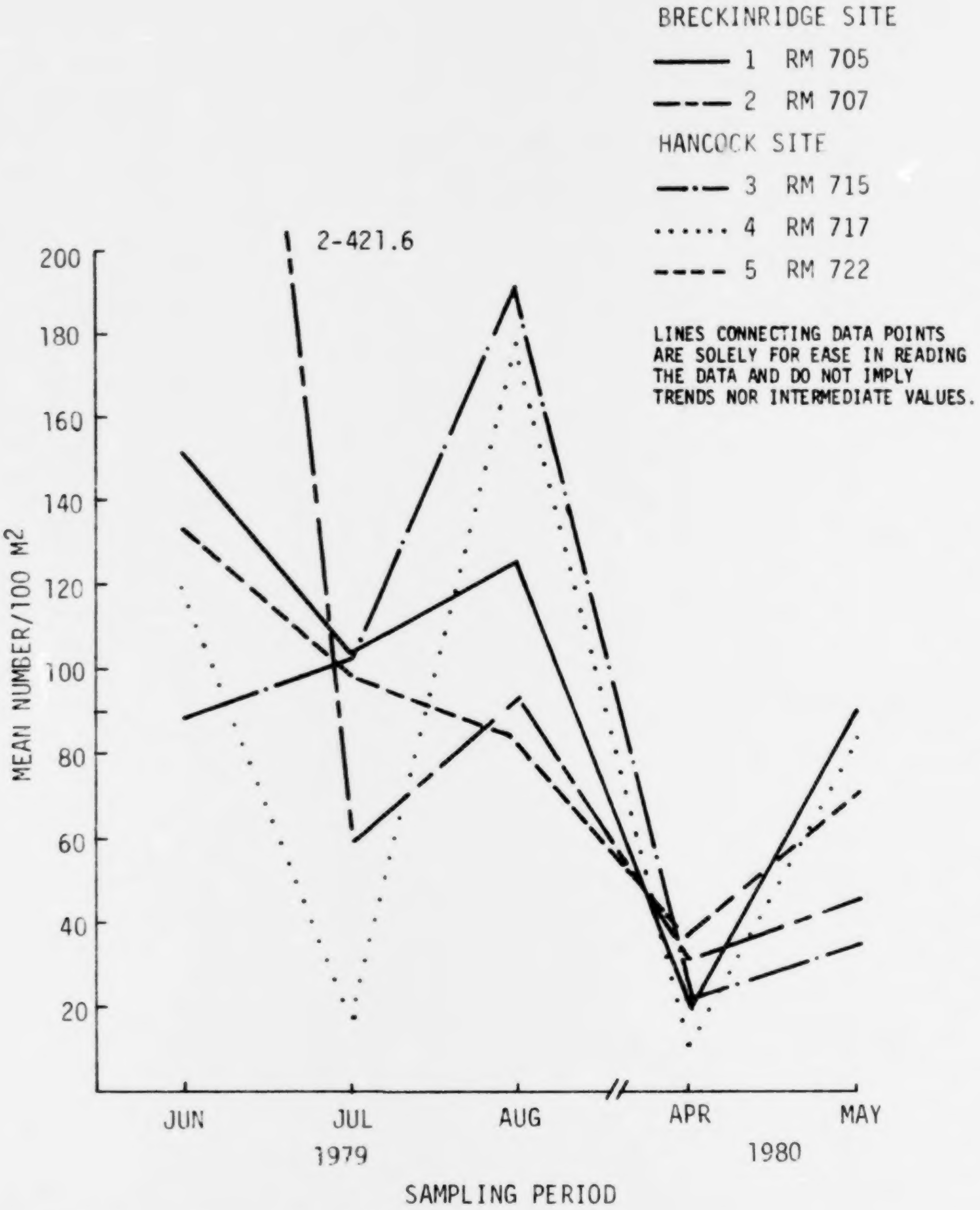
Surveys conducted from 1963 to 1967 at RM 787.5 revealed higher densities of macrobenthic organism but generally similar taxa to those found between RM 705-722 in 1979-80 (Mason et al. 1971). As in the earlier study, few stoneflies, mayflies, and caddisflies were collected and the dominant organisms were pollution-tolerant or facultative species.

3.4.2 Hancock Site

3.4.2.1 Ohio River Miles 715-722

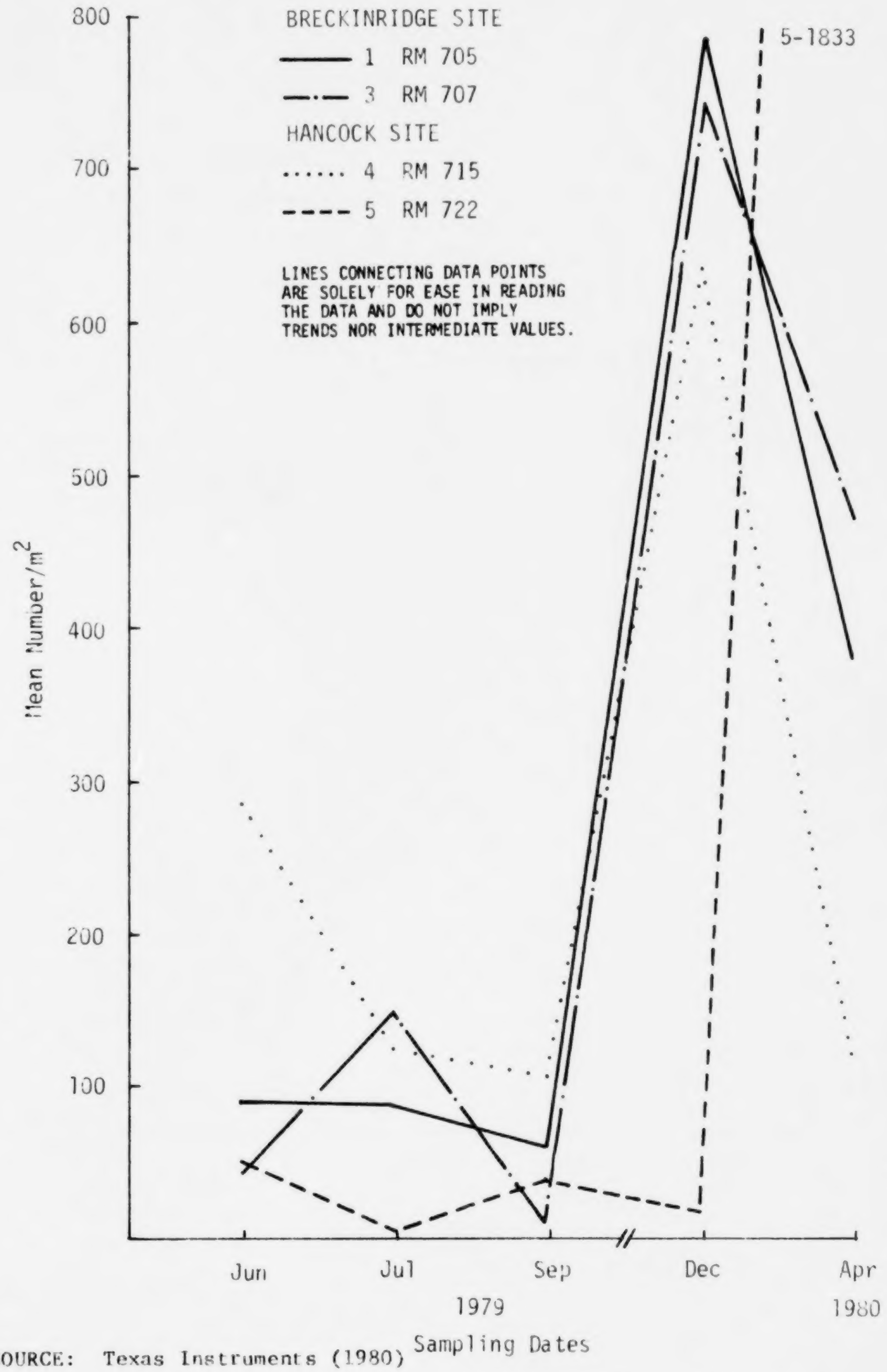
3.4.2.1.1 Fish

Forage fish, including herrings, the emerald shiner, and the gizzard shad, are the dominant fish in the Ohio River adjacent to the Hancock site (Tables 3.4-11, 3.4-12, 3.4-13). Rough fish, especially suckers, are the next most abundant, and commercially important species and game fish are the least abundant. The freshwater drum appears to be the most consistently abundant commercial fish in the area, while the largemouth bass, white crappie, sauger,



SOURCE: Texas Instruments (1980)

Figure 3.4-10. Mean Numbers (per 100 m^3) of Macrozooplankton, Ohio River Miles 705, 707, 715, 717, and 722, 1979-1980



SOURCE: Texas Instruments (1980)

Figure 3.4-11. Mean Numbers (per m^2) of Bottom Organisms, Ohio River Miles 705, 707, 715, and 722, 1979-1980

Table 3.4-11. Total Catch, Mean Length, and Mean Weight of Seined Fish, Ohio River Miles 705, 707, 717, and 722, 1979-1980 (Sheet 1 of 2)

Taxon	RM 705						RM 707						RM 717						RM 722					
	1979			1980			1979			1980			1979			1980			1979			1990		
	Jun*	Jul*	Jul 29	Apr	May	Jun	Jun*	Jul*	Jul 29	Apr	May	Jun	Jun*	Jul*	Jul 29	Apr	May	Jun	Jun*	Jul*	Jul 29	Apr	May	Jun
Longnose gar																								
Total Catch								1		1														
Mean Length (mm)								579.0		290.0														
Mean Weight (gm)								290.0		410.0														
Skipjack herring																								
Total Catch	1	47	2					1598	3					22	2					2				
Mean Length (mm)	28.0	33.1	108.0					36.3	59.7					29.2	118.0					27.0				
Mean Weight (gm)	0.1	0.3	11.1					0.5	1.7					0.2	10.7					0.1				
Gizzard shad																								
Total Catch		2	1	3	1	1		1	2		4		1	1	1	2	3		1	3				1
Mean Length (mm)		185.5	196.0	146.5	200.0	218.0		28.0	201.0		202.5		165.0	21.0	182.0	129.3	177.3		174.0	191.7				210.0
Mean Weight (gm)		59.4	73.3	40.0	72.0	81.0		0.2	79.8		75.0		43.3	–	62.8	56.7	52.3		39.9	59.0				81.0
Herring (U)																								
Total Catch								1						4										
Mean Length (mm)								22.0						22.2										
Mean Weight (gm)								0.1						0.1										
Goldeye																								
Total Catch																				1				
Mean Length (mm)																				222.0				
Mean Weight (gm)																				96.2				
Silver chub																								
Total Catch		10	1					3	3					3	7					2				
Mean Length (mm)		64.7	38.0					68.0	42.0					80.9	56.6					102.3				
Mean Weight (gm)		4.2	0.4					4.9	0.7					7.0	1.8					1.4				
Emerald shiner																								
Total Catch	8	1295	36				6	2704	106		2	2	1	1353	293				13	11	14			
Mean Length (mm)	61.3	29.0	43.8				70.2	31.9	42.1		49.0	57.0	66.0	29.2	36.7				74.5	67.6	33.2			
Mean Weight (gm)	1.9	0.2	0.5				24	0.2	0.5		0.8	1.6	2.2	0.2	0.3				3.0	3.2	0.3			
Bullhead minnow																								
Total Catch												1								1	1			
Mean Length (mm)												77.0								84.0	45.0			
Mean Weight (gm)												5.8								5.5	1.1			

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*June and July 1979 included two sampling periods; all other months included one sampling.

– Data missed

U = not identified to species.

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.4-11. Total Catch, Mean Length, and Mean Weight of Seined Fish, Ohio River Miles 705, 707, 717, and 722, 1979-1980 (Sheet 2 of 2)

	RM 705						RM 707						RM 717						RM 722					
	1979			1980			1979			1980			1979			1980			1979			1980		
Taxon	Jun*	Jul*	Jul 29	Apr	May	Jun	Jun*	Jul*	Jul 29	Apr	May	Jun	Jun*	Jul*	Jul 29	Apr	May	Jun	Jun*	Jul*	Jul 29	Apr	May	Jun
Golden redhorse																								
Total Catch												1												
Mean Length (mm)												63.0												
Mean Weight (gm)												2.6												
River shiner																								
Total Catch							1																	
Mean Length (mm)							52.0																	
Mean Weight (gm)							1.4																	
Mimic shiner																								
Total Catch							2													1				
Mean Length (mm)							34.0													47.0				
Mean Weight (gm)							0.4													1.1				
Minnows (U)																								
Total Catch	2	3	1				11	2	1						2				2	5	1			
Mean Length (mm)	15.0	17.0	19.0				21.2	27.5	19.0						25.0				20.5	27.4	20.0			
Mean Weight (gm)	0.1	0.1	0.1				0.1	0.2	0.0						0.3				0.1	0.3	0.0			
Suckers (U)																								
Total Catch								1																
Mean Length (mm)								34.0																
Mean Weight (gm)								0.1																
Bluegill																								
Total Catch									1					1										
Mean Length (mm)									158.0					181.0										
Mean Weight (gm)									61.0					90.0										
Largemouth bass																								
Total Catch							1																	
Mean Length (mm)							36.0																	
Mean Weight (gm)							0.4																	
Logperch																								
Total Catch							1																	
Mean Length (mm)							33.0																	
Mean Weight (gm)							0.3																	
Sauger																								
Total Catch							1					1												
Mean Length (mm)							34.0					40.0												
Mean Weight (gm)							0.2					0.5												
Freshwater drum																								
Total Catch		2							1	1				1			1	1						1
Mean Length (mm)		22.5							51.0	150.0				151.0			154.0	273.0						[illegible]
Mean Weight (gm)		0.1							1.2	55.0				33.6			140.0	373.0						327.0

Table 3.4-12. Total Catch, Mean Length, and Mean Weight of Electroshocked Fish, Ohio River Miles 705, 707, Mouth of Town Creek, 715, 717, and 722, 1979-1980 (Sheet 1 of 4)

	RM 705						RM 707						Mouth Town Creek					
	1979			1980			1979			1980			1979			1980		
Taxon	Jun	Jul	Aug	Apr	May	Jun*	Jun	Jul	Aug	Apr	May	Jun*	Jun	Jul	Aug	Apr	May	Jun*
Longnose gar																		
Mean Length (mm)		601.0								421.0								
Mean Weight (gm)		390.0								1217.0								
Number		1								1								
Skipjack herring																		
Mean Length (mm)								36.5	118.0									
Mean Weight (gm)								28.0	12.2									
Number								2	1									
Gizzard shad																		
Mean Length (mm)	183.9	217.5	197.8	177.3	191.3		180.1	186.2	229.2	175.5		198.5	193.8	194.0	236.4	167.2	200.0	
Mean Weight (gm)	52.0	27.5	63.3	60.6	73.7		57.5	27.3	95.7	60.3		80.0	62.0	57.0	111.4	51.0	71.3	
Number	12	4	9	11	3		12	6	14	4		2	5	5	14	6	6	
Mooneye																		
Mean Length (mm)								209.0										
Mean Weight (gm)								70.0										
Number								2										
Goldfish																		
Mean Length (mm)														265.0				
Mean Weight (gm)														270.0				
Number														1				
Carp																		
Mean Length (mm)							535.0						441.5		515.0			
Mean Weight (gm)							2060.0						1440.0		600.0			
Number							1						2		1			
Silver chub																		
Mean Length (mm)		111.0							54.0									
Mean Weight (gm)		13.3							1.4									
Number		1							1									
Emerald shiner																		
Mean Length (mm)		58.7													41.9			
Mean Weight (gm)		2.1													0.5			
Number		6													8			
Golden shiner																		
Mean Length (mm)													183.0					
Mean Weight (gm)													70.0					
Number													1					
River carpsucker																		
Mean Length (mm)							452.0							396.0	363.5		340.0	
Mean Weight (gm)							1080.0							820.0	585.0		918.0	
Number							1							1	2		1	
Channel catfish																		
Mean Length (mm)							400.0											
Mean Weight (gm)							238.0											
Number							2											

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*Represents one sampling date; all other sampling periods represent two sampling dates.

U = not identified to species.

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.4-12. Total Catch, Mean Length, and Mean Weight of Electroshocked Fish, Ohio River Miles 705, 707, Mouth of Town Creek, 715, 717, and 722, 1979-1980 (Sheet 2 of 4)

	RM 705						RM 707						Mouth Town Creek					
	1979			1980			1979			1980			1979			1980		
Taxon	Jun	Jul	Aug	Apr	May	Jun*	Jun	Jul	Aug	Apr	May	Jun*	Jun	Jul	Aug	Apr	May	Jun*
Flathead catfish																		
Total Length (mm)			351.8					660.0							137.0			
Total Weight (gm)			436.0					3450.0							22.6			
Number			5					1							1			
White bass																		
Mean Length (mm)	261.0							162.0					182.0					
Mean Weight (gm)	160.0							48.5					60.0					
Number	1							1					1					
Green sunfish																		
Mean Length (mm)														193.0				
Mean Weight (gm)														120.0				
Number														1				
Bluegill																		
Mean Length (mm)	179.0						157.2							164.0	148.7			
Mean Weight (gm)	110.0						95.0							90.0	58.3			
Number	1						4							3	6			
Longear sunfish																		
Mean Length (mm)													170.0					
Mean Weight (gm)													188.7					
Number													3					
Smallmouth bass																		
Mean Length (mm)														266.0	233.0			
Mean Weight (gm)														250.0	120.0			
Number														1	1			
Largemouth bass																		
Mean Length (mm)							256.0											
Mean Weight (gm)							140.0											
Number							2											
White crappie																		
Mean Length (mm)							255.5											
Mean Weight (gm)							160.0											
Number							2											
Sunfish (U)																		
Mean Length (mm)	171.0																	
Mean Weight (gm)	100.0																	
Number	1																	
Walleye	275.0																	
Mean Length (mm)	160.0																	
Mean Weight (gm)	1																	
Number																		
Freshwater drum																		
Mean Length (mm)							151.0	191.7					164.5	163.0		227.0	237.0	
Mean Weight (gm)							100.0	59.1					37.5	36.7		192.0	219.0	
Number							1	3					4	3		1	1	

Table 3.4-12. Total Catch, Mean Length, and Mean Weight of Electroshocked Fish, Ohio River Miles 705, 707, Mouth of Town Creek, 715, 717, and 722, 1979-1980 (Sheet 3 of 4)

	RM 715						RM 717						RM 722					
	1979			1980			1979			1980			1979			1980		
Taxon	Jun	Jul	Aug	Apr	May	Jun*	Jun	Jul	Aug	Apr	May	Jun*	Jun	Jul	Aug	Apr	May	Jun*
Longnose gar																		
Mean Length (mm)	542.0								577.7	483.0	467.0		277.6					
Mean Weight (gm)	220.0								323.3	1121.0	1239.0		155.0					
Number	1								3	1	1		12					
Skipjack herring																		
Mean Length (mm)														30.0				
Mean Weight (gm)														29.0				
Number														2				
Gizzard shad																		
Mean Length (mm)	183.7	266.2	218.1	161.2			229.2	134.0	299.8				197.5	196.1	214.9	183.5	207.3	205.4
Mean Weight (gm)	70.5	75.9	88.0	51.4			123.9	25.5	246.0				90.3	98.2	84.4	63.6	77.9	76.0
Number	19	11	45	5			9	1	5				30	20	40	14	10	5
Goldfish																		
Mean Length (mm)													304.5					
Mean Weight (gm)													535.0					
Number													2					
Carp																		
Mean Length (mm)	312.0							419.0					475.0	445.0				
Mean Weight (gm)	460.0							860.0					1600.0	1137.0				
Number	1							1					2	4				
Silver chub																		
Mean Length (mm)	103.0	93.0																
Mean Weight (gm)	9.0	7.2																
No.	1	1																
Emerald shiner																		
Mean Length (mm)								65.0						24.1				
Mean Weight (gm)								2.2						0.1				
Number								1						20				
River carpsucker																		
Mean Length (mm)	422.0	379.5	410.2	403.0			353.0	341.6	368.6				405.0	320.0	365.3		431.0	
Mean Weight (gm)	1020.0	800.0	838.5	569.6			595.0	504.3	632.0				780.0	410.0	576.7		336.0	
Number	1	2	13	2			4	7	5				1	2	3		1	
Channel catfish																		
Mean Length (mm)														497.7				
Mean Weight (gm)														2518.7				
Number														3				
Flathead catfish																		
Mean Length (mm)	375.0		350.0											572.0	420.0	620.5		
Mean Weight (gm)	520.0		395.1											2180.0	480.0	1628.5		
Number	1		7											1	1	2		

Table 3.4-12. Total Catch, Mean Length, and Mean Weight of Electroshocked Fish, Ohio River Miles 705, 707, Mouth of Town Creek, 715, 717, and 722, 1979-1980 (Sheet 4 of 4)

	Rm 715						Rm 717						RM 722					
	1979			1980			1979			1980			1979			1980		
Taxon	Jun	Jul	Aug	Apr	May	Jun*	Jun	Jul	Aug	Apr	May	Jun*	Jun	Jul	Aug	Apr	May	Jun*
White bass																		
Mean Length (mm)								251.0										
Mean Weight (gm)								80.0										
Number								1										
Green sunfish																		
Mean Length (mm)	161.5	179.0																
Mean Weight (gm)	110.0	120.0																
Number	2	1																
Pumpkinseed																		
Mean Length (mm)													125.3					
Mean Weight (gm)													43.3					
Number													3					
Warmouth																		
Mean Length (mm)													111.5					
Mean Weight (gm)													31.3					
Number													2					
Bluegill																		
Mean Length (mm)		176.0	179.0										133.8	124.3	180.0		148.0	162.5
Mean Weight (gm)		130.0	50.0										56.9	40.8	80.0		42.0	51.0
Number		1	1										27	18	1		1	2
Longear sunfish																		
Mean Length (mm)													93.3	114.7				
Mean Weight (gm)													23.0	33.1				
Number													7	8				
Smallmouth bass																		
Mean Length (mm)													229.0			110.0		
Mean Weight (gm)													130.0			62.0		
Number													1			1		
Largemouth bass																		
Mean Length (mm)													233.0	289.0	249.5			
Mean Weight (gm)													160.0	190.0	140.0			
Number													1	1	2			
White crappie																		
Mean Length (mm)													126.0	138.3		152.0		147.0
Mean Weight (gm)													23.1	31.0		64.0		42.0
Number													1	3		1		1
Sauger																		
Mean Length (mm)								182.0										
Mean Weight (gm)								40.9										
Number								1										
Freshwater drum																		
Mean Length (mm)	162.0	159.0		241.0	219.3	231.5			577.7				155.4					
Mean Weight (gm)	70.00	80.0		302.0	236.7	264.5			323.3				56.4					
Number	1	1		1	3	2			3				11					

Table 3.4-13. Catch per Unit Effort, Mean Length, and Mean Weight of Gillnetted Fish, Ohio River Miles 707, 720, and 722, 1979-1980

	1979												1980											
	June				July				August				April				May				June			
Taxon	RM 707	RM 720	RM 722	Rel. Abun.*	RM 707	RM 720	RM 722	Rel. Abun.	RM 707	RM 720	RM 722	Rel. Abun.	RM 707	RM 720	RM 722	Rel. Abun.	RM 707	RM 720	RM 722	Rel. Abun.	RM 707	RM 720	RM 722	Rel Abun.
Longnose gar				4.9				20.8				11.6				44.9				25.3				100.0
C/F**			1.3				4.5				3.9				2.9				0.6			3.4		
Mean Length (mm)			667.0				715.2				703.8				499.0				420.0			214.3		
Mean Weight (gm)			630.0				913.3				690.0				1342.4				1800.0			77.7		
Gizzard shad				12.5				21.1				2.6				18.4								
C/F	3.4	0.6	2.5		2.0	2.5			2.0	0.4			0.5	0.6										
Mean Length (mm)	289.3	187.0	290.5		190.0	247.4			239.8	298.0			125.0	120.0										
Mean Weight (gm)	190.0	20.0	190.0		20.0	88.0			124.0	270.0			30.0	40.0										
Goldeye												30.5												
C/F									3.9	3.7	1.2													
Mean Length (mm)									325.6	289.7	358.3													
Mean Weight (gm)									295.0	175.6	376.7													
Mooneye								11.4				25.0												
C/F					1.0	1.0	0.5		2.7	3.7														
Mean Length (mm)					359.0	260.0	294.0		212.0	287.7														
Mean Weight (gm)					300.0	95.0	240.0		65.7	178.7														
Stoneroller												2.7												
C/F											0.4													
Mean Length (mm)											540.0													
Mean Weight (gm)											1200.0													
Carp				4.8				9.1				2.3												
C/F	1.1	1.2			1.0	0.5	0.5		0.4		1.6													
Mean Length (mm)	489.0	471.5			597.0	516.0	631.0		568.0		571.0													
Mean Weight (gm)	1488.0	1650.0			2480.0	2580.0	2560.0		2300.0		1971.0													
River carpsucker				4.7				5.1				2.0				20.2								
C/F	1.7	1.1					1.1				0.4			1.3										
Mean Length (mm)	434.3	4325.0					477.0				443.0			519.5										
Mean Weight (gm)	946.7	1080.0					975.0				1120.0			1181.0										
Channel catfish				2.4				9.3				0.7												
C/F	1.1	0.6			1.0	1.0			1.6		0.8													
Mean Length (mm)	415.0	362.0			254.0	264.0			468.7		303.0													
Mean Weight (gm)	690.0	440.0			70.0	60.0			1313.3		287.7													
Flathead catfish												14.3												
C/F									1.2	1.6														
Mean Length (mm)									665.7	486.7														
Mean Weight (gm)									3523.3	1315.0														
White crappie												0.2												
C/F									0.8															
Mean Length (mm)									252.5															
Mean Weight (gm)									200.0															
White bass				0.1				4.6																
C/F	0.6				1.0																			
Mean Length (mm)	277.0				270.0																			
Mean Weight (gm)	220 0				180.0																			
Walleye				7.1								7.2												
C/F	1.7	1.8							3.9	1.2														
Mean Length (mm)	281.0	391.0							326.5	327.3														
Mean Weight (gm)	150.0	433.3							272.0	193.3														
Bluegill								2.3																
C/F						0.5																		
Mean Length (mm)						153.0																		
Mean Weight (gm)						20.0																		
Freshwater drum				63.5				16.3				0.8				16.6				74.7				
C/F	2.8	1.1	15.2		1.0	0.5	2.0		3.1				1.1					1.9						
Mean Length (mm)	196.4	224.5	279.7		313.0	307.0	312.2		234.6				154.5					156.7						
Mean Weight (gm)	90.0	95.0	212.5		230.0	270.0	325.0		116.2				296.5					111.7						
Total Fish Caught		48				36				97				11				4				3		
Total Taxa		8				9				12				4				2				1		

*Relative Abundance = C/F per 24 hr.

**C/F = Catch/unit effort based on 24-hr set time.

Source: Texas Instruments Incorporated field data (1979-1980).

walleye, and white bass are important among the low numbers of game species present.

Twenty-nine species were collected from RM 715 to 722 during 1979-1980. Five of the six species mentioned as previously unreported from the Cannelton Lock and Dam (the stoneroller, bullhead minnow, mimic shiner, johnny darter, and pumpkinseed sunfish) were taken at the Hancock site. Greatest overall numbers of adult and juvenile fish apparently occur in July and August. There is considerable variation in spatial and temporal distribution of fish populations from RM 715 to 722 between April and August, probably because of variability in habitat and movement up- and down-river (Figures 3.4-6, 3.4-7, 3.4-8).

3.4.2.1.2 Macroplankton and Macrobenthos

Fish Eggs and Larvae. Herrings, minnows, and other forage fish also dominate fish eggs and larvae from RM 715 to 722 (Table 3.4-14). Freshwater drum eggs and larvae, which appear to be present in greater proportion than the adults, are abundant. Sport fish eggs and larvae are in low numbers, as are the adults, and paddlefish larvae are rare. Larvae of the paddlefish, which is on the Kentucky Nature Preserves Commission Animal Element List, were collected at RM 717.

Greatest overall density of this component of the macroplankton appears to be at RM 715. Temporally, greatest overall density occurs in June and July (Figure 3.4-9). Densities and taxa generally are similar from nearshore to mid-river and from surface to bottom, although considerable variability is not uncommon. Their planktonic nature and the turbulent nature of the Ohio River seem to produce a rather even distribution of fish eggs and larvae.

Macrozooplankton. Other common to abundant fauna among the macroplankton inhabiting RM 715 to 722 are cladocerans, hydrozoans (Cnidaria), caddisflies (Trichoptera), mayflies (Ephemeroptera) and aquatic flies (Diptera) (Table 3.4-15). Cladocerans apparently are the dominant macrozooplankton and are most dense during summer. Hydrozoans are most common during early summer. Densities of the other plankton forms appear to be considerably less than both groups during their peak. Oligochaete abundance may be high in May and June, although, as mentioned, these species generally do not comprise such a large portion of the planktonic fauna and net dragging during sampling probably produced these results. Greatest macrozooplankton density in the Ohio River adjacent to the Hancock site was noted in August (Figure 3.4-10).

Macrobenthos. Oligochaetes, dominated by tubificid worms are by far the most abundant bottom dwelling macroorganisms in the Ohio River adjacent to the Hancock site (Table 3.4-16). Several genera of midges comprise the second most abundant group. Densities of macrobenthos in this section of the river appear to be greatest in winter and spring (Figure 3.4-11). Especially large numbers of macrobenthic organisms noted at RM 722 in April 1980 represent overwinter recolonization of the heavily scoured area below the lock and dam. Species composition is similar to that reported in an earlier study, although densities are lower. The presence of few pollution-sensitive species, especially notable among the aquatic insects, reflects the status of development along the river.

Table 3.4-14. Monthly Mean Numbers (per 100 m^3) of Fish Eggs and Larvae, Ohio River Miles 715, 717, and 722, Hancock Site, 1979-1980

	RM 715						RM 717						RM 722					
	1979			1980			1979			1980			1979			1980		
Taxon	Jun	Jul	Aug	Apr	May	Jun 4*	Jun	Jul	Aug	Apr	May	Jun 4*	Jun	Jul	Aug	Apr	May	Jun 4*
Eggs																		
Fish (U)													0.08				0.09	0.33
Emerald shiner																		
Sucker				0.10														
Freshwater drum	2.07	0.05					1.08	0.06	0.01		0.10		1.32	1.40				
Larvae																		
Fish (U)	13.59	1.8	0.17	0.09	0.75	1.11	10.38	1.14		0.18	0.35	0.36	13.36	1.54	0.11	0.17	0.19	
Paddlefish										0.08								
Gar spp.							0.15											
Shad spp.				0.09	0.10		0.09				0.08			0.14		0.09	0.09	
Skipjack herring	0.48	0.19					0.17					3.61	0.31				0.11	
Gizzard shad							0.09											
Herring spp.	995.74	186.64		0.09	2.42	8.36	118.16	42.18		0.62	5.99		224.09	26.11		0.17	2.18	4.64
Mooneye										0.09							0.10	
Carp	19.65	1.04		0.09	5.25	9.20	5.77	0.81	0.08	0.41	3.82	1.81	6.09	0.20			2.75	4.60
Emerald shiner	9.19	48.25	0.07			1.77	6.84	12.12			0.83		4.37	5.14	0.28		1.15	3.90
Minnows and shiners	0.51		0.16		0.20			0.09	0.09		0.19		0.07	0.37	0.24		0.46	0.33
Sucker spp.	21.80	21.52	0.23	32.08	4.94	46.97	9.09	1.32	0.16	10.22	4.50	17.01	31.45	25.88	0.53	16.09	3.24	34.38
White bass	2.13					0.35					0.19	0.72	0.88			0.09		
Lepomis spp.	2.26				0.09		1.05	0.01			0.18		0.54	0.24				
Pomoxis spp.	3.12						0.66											
Micropterus spp.					0.10						0.08							
Sunfish spp.	0.72						0.44											
Sauger				0.34						0.09								
Johnny darter							0.08											
Freshwater drum	822.58	11.98	2.69		0.95	6.10	112.41	17.77	1.71		1.13	1.81	135.86	15.92	0.78		1.77	7.30

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*Represents one sampling date; all other sampling periods represent 4 sampling dates.

Collection made with 0.5-meter hoop net (505-μm mesh).

U = unidentified.

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.4-15. Mean Numbers (per 100 m^3) of Macrozooplankton, Ohio River Miles 715, 717, and 722, Hancock Site, 1979-1980

	RM 715					RM 717					RM 722				
	1979			1980		1979			1980		1979			1980	
Taxon	Jun	Jul	Aug	Apr	May	Jun	Jul	Aug	Apr	May	Jun	Jul	Aug	Apr	May
Cnidaria															
Hydra spp.	7.85	0.27	4.11			80.66	0.23	2.11		1.86	76.32	1.22	1.06	0.36	0.75
Cordylophora lacustris				0.30	1.51					1.53				0.34	1.48
Craspedacusta sowerbyi										0.37					1.09
Nematoda															
Nematode (U)										0.27					0.38
Oligochaeta															
Chaetogaster spp.				0.73					0.67						
Naididae (U)	0.60			5.07	12.00				2.01	30.28	0.51		0.27	1.39	31.58
Tubificidae (U)											200.87				
Oligochaete (U)											0.77	0.25	0.27		
Gastropoda															
Gastropoda (U)		0.25													
Bivalvia															
Bivalvia (U)										0.37					
Arachnida															
Hydracarina spp.	0.27					0.97		0.26			0.51				
Cladocera															
Bosmonidae (U)		0.21									0.33			0.24	
Chydorus spp.														0.61	
Daphnia galeata mendotae	0.67	0.43	3.94					3.60			0.26	0.76	2.15		
D. retrocurva			11.54					9.27	0.35				1.11	0.36	
D. pulex	21.13	1.47		1.41	1.54	2.82			1.45	2.61	4.98	1.19			1.18
D. parvula	31.26	68.43	122.69	0.30	1.47	16.36	18.19	127.94	0.64	1.45	11.80	45.87	59.21		2.61
D. spp.		3.16	1.28			0.29	0.52			0.37	1.73	2.05	1.60		
Simocephalus spp.	5.03	0.43				1.41			0.33		7.34	0.24			
Ceriodaphnia spp.	0.67					0.35				0.75					
Scapholeberis spp.	0.93			0.29					0.38	0.39	0.77				0.43
Moina spp.		0.23	10.48					18.24					6.21		
Daphnidae (U)												0.72		0.34	
Leptodora kindtii		3.37					1.51	0.26			0.33	30.94			
Ilyocryptus sordidus												0.73			
I. spp.														0.31	
Sida crystallina	2.74	0.21	6.43			0.98	0.02	6.53	0.35		3.59	0.24	3.85		
Diaphanosoma spp.			0.63				0.25	2.20			0.26	0.27	0.55		0.43
Sididae (U)							0.20					2.69			
Cladocera (U)												0.48			
Ostracoda															
Ostracoda (U)						1.38									
Copepoda															
Diaptomus oregonensis	1.90	0.92	0.29									0.23			
D. siciloides	1.93	0.25			0.74					9.62	1.10		0.34	26.38	2.58
D. sicilis											0.26				
D. birgei	0.33				1.18						0.51				
D. pallidus					2.24										1.10
D. spp.		0.47	0.43	0.29	2.78		0.80	0.30	1.35	9.75	0.77		0.51		1.06
Osphranticum labronectum	0.34										0.56				
Eurytemora affinis														2.85	
Calanoida (U)	0.60	2.16		0.30		1.04	0.22				3.36	2.00			
Cyclops vernalis	0.52			2.00	3.41				0.65	13.51					6.74
C. bicuspidatus thomasi										0.37					
Macrocyclops albidus	2.58					1.42					2.21				
Mesocyclops edax	2.00	0.45	0.68	0.35		1.05	0.69			0.34	0.77	0.70	0.23		
Cyclopoida (U)	0.27	0.49		0.34						0.78	1.28	0.25		0.72	
Copepoda (U)											0.26				
Branchiura															
Argulus spp.	0.86										1.02				
Amphipoda															
Liljeborgiidae (U)															2.92
Gammaridae (U)	1.01	3.07		4.73	4.01	1.77	2.31		1.34	5.10	0.92	0.50		0.34	3.03
Amphipoda (U)												0.24			
Collembola															
Collembola (U)															0.37
Ephemeroptera															
Baetidae (U)				0.30				0.30					0.28		0.38
Heptageniidae (U)		1.96	11.84	0.63	1.18	0.35		0.88	0.68	0.39	0.89	1.44	1.10		1.46
Caenidae (U)	0.33	1.47									0.26	0.96			
Ephemeroptera (U)	0.31			0.67	0.37									2.02	
Odonata															
Coenagrionidae (U)										0.74					
Coleoptera															
Elmidae (U)															0.37
Trichoptera															
Hydrosychidae (U)	0.34		11.91	2.51	0.75	0.69		3.57	0.35	0.71	7.57	0.51	5.01	1.37	1.30
Trichoptera (U)			2.80					1.19					0.55		
Diptera	2.87	9.76				11.14					2.98	3.14			
Chaoborus spp.	0.93	8.89	0.91				2.27	0.55			1.86	0.95	0.55	0.34	0.43
Chironomus spp.									0.67						
Chironomidae (U)	1.94	0.87	1.40		2.22	11.14	0.01	0.60		3.29	1.10	2.19		0.70	1.40
Diptera (U)			1.46										0.28		
Ectoprocta															
Ectoprocta (U)		1.20					[illegible]								

U = not identified to genus or species.

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.4-16. Mean Numbers (per m^2) of Bottom Organisms, Ohio River Miles 705, 707, 717, and 722, 1979-1980

	Breckinridge Site										Hancock Site									
	RM 705					RM 707					RM 717					RM 722				
	1979				1980	1979				1980	1979				1980	1979				1980
Taxon	Jun	Jul	Sep	Dec	Apr	Jun	Jul	Sep	Dec	Apr	Jun	Jul	Sep	Dec	Apr	Jun	Jul	Sep	Dec	Apr
Platyhelminthes																				
Turbellaria (U)										25.64					6.41					
Nemertina																				
Nemertina (U)					6.41															
Nematoda																				
Nematoda (U)	6.41		12.82				6.41			6.41	6.41	12.82								
Oligochaeta																				
Naididae (U)			12.82		44.87					19.23										32.05
Tubificidae (U)	57.69	64.10	25.64	570.51	192.31	25.64	89.74	6.41	730.77	378.20	230.77	102.56		544.87	38.46	12.82		12.82		1801.28
Bivalvia																				
Bivalvia (U)					6.41	12.82			6.41	6.41			6.41	70.51						
Corbicula manilensis					19.23								6.41	19.23	6.41			12.82		
Sphaerium spp.									6.41											
Plecoptera																				
Isoperla spp.																			6.41	
Isopoda																				
Asellus spp.										6.41										
Amphipoda																				
Amphipoda (U)											6.41									
Gammarus spp.							32.05			6.41	25.64	6.41				12.82				
Tricoptera																				
Hydropsychidae (U)									6.41											
Potamyia flava		6.41		6.41									25.64	12.82	25.64					
Polycentropodidae (U)													6.41							
Cyrnellus spp.										6.41										
Diptera																				
Ceratopogonidae (U)					57.69										6.41					
Chironomidae (U)	25.64															12.82				
Cryptochironomus spp.																		6.41		
Procladius spp.										6.41								6.41		
Polypedilum spp.		6.41	12.82	198.72	44.87		6.41	12.82		6.41					38.46	12.82	6.41			
Chironomus spp.											12.82								6.41	
Ablabesmyia spp.	6.41																			
Xenochironomus spp.						6.41					6.41		64.10	6.41						
Tanytarsus spp.										6.41		6.41							6.41	
Coeltanypus spp.							6.41													
Paracladopelma spp.							6.41													
Robackia spp.	12.82																			
Chaoborus spp.									6.41											
Ectoprocta																				
Lephopodella carteri				6.41																
Pectinetella magnifica					6.41															

U = not identified to genus or species.

Source: Texas Instruments Incorporated field data (1979-1980).

3.4.2.2 Hancock Site Streams

Indian Creek is the largest of the site's three streams. It is a permanent stream having observed velocities of less than 0.1 foot/second during the 1979-1980 onsite study (Table 3.4-17). Its banks, which mostly are sandstone and limestone, are lined with lowland deciduous forest vegetation, although most of its onsite length is in an agricultural setting.

Sandy Branch and Muddy Branch maintained respective velocities of 0.8 to 1.6 feet/second and 0.9 to 1.3 feet/second during the onsite study. Neither is intermittent, although both headwaters could be dry during periods of below normal rainfall. Both drain agricultural and deciduous forest upland areas and flow the greater part of their length through the Ohio River alluvium. Sampling stations on both were in locations of silty/sandy substrate rather than sandstone. Like Indian Creek, their banks are lined with deciduous forest vegetation for the most part.

3.4.2.2.1 Water Quality

Present water quality of the Hancock site streams (Table 3.4-17) is representative of relatively unpolluted upland streams of the eastern deciduous forest. No specific water quality problems are apparent and values of the parameters analyzed during the 1979-80 onsite study mostly were within standards of the Kentucky DNREP, Division of Water Quality. One dissolved oxygen observation from Indian Creek (4.1 mg/l in August 1979) was near the DNREP standard for instantaneous minimum concentration (4 mg/l), and in May 1980, all three streams exhibited pH values below the 6.0 standards.

3.4.2.2.2 Fish

Dominant groups of fish in the Hancock site streams are minnows and shiners, with the creek chub and southern redbelly dace the most abundant species (Table 3.4-18). The blue gill apparently is the most abundant of the few game fish present, and there is no significant fishery onsite except recreational bank fishing on Indian Creek. Greatest numbers of fish were collected in July (174 total), reflecting low water levels and greater concentrations of fish at that time. Low numbers collected in April and May (3 and 17, respectively) reflect higher water levels and greater dispersal of fish. At least 19 species occur on the site, all generally reported from this part of Kentucky (Clay 1975). One species, the pirate perch, is on the Kentucky Nature Preserves Commission Animal Element List. Figure 3.4-12 shows numbers of fish collected in each sampling period from each stream.

3.4.2.2.3 Macroinvertebrates

In contrast to the Ohio River, dominant bottom dwelling fauna in the onsite streams are midges, with oligochaetes the second most abundant group (Table 3.4-19). Diversity of midges, and benthos in general, is higher on the site than in the river (48 taxa collected onsite vs. 27 collected from RM 715 to 722, in 1979-1980). Species composition also differs, and both observations reflect better water quality as well as different types of habitats and a greater variety of them. The predominance of insects over tubificid worms also may be indicative of better water quality and consequently a better supply of predators (Smith 1974). Densities of midges in the onsite benthos appear to be

Table 3.4-17. Water Quality of Streams on the Hancock and Breckinridge Sites, 1979-1980

Parameter	Indian Creek							Muddy Branch							Sandy Branch						
	1979			1980				1979			1980				1979			1980			
	Aug	Sep	Dec	Apr	May	Jun	Jul	Aug	Sep	Dec	Apr	May	Jun	Jul	Aug	Sep	Dec	Apr	May	Jun	Jul
HANCOCK SITE																					
Dissolved oxygen (mg/ℓ)	4.1	6.4	7.0	12.4	8.9	8.8	8.5	6.3	6.5	5.6	13.2	9.2	7.2	8.0	8.5	6.3	6.2	13.6	11.2	8.4	8.4
Temperature (°C)	22.2	20.5	5.4	12.7	15.9	20.8	29.2	21.0	21.5	5.4	12.2	16.1	21.2	28.0	21.5	21	5.5	14.2	14.3	16.8	27.8
pH	6.3	6.9	6.0	6.7	5.3	6.5	6.7	6.7	6.9	6.4	6.8	5.5	6.4	6.8	6.0	7.3	6.1	6.4	5.6	6.4	6.6
Total dissolved solids (mg/ℓ)	229	98	173	236	257	247	134	135	85	192	110	128	127	138	159	97	99	165	182	166	151
Total suspended solids (mg/ℓ)	12	50	149	13	15	30	123	5	15	68	17	9	9	14.7	2	24	55	6	6	6	58
Turbidity (NTU)	11	47	68	–*	6	14	38	7	24	44	–*	7	7	65	3	22	36	–*	5	3	34
Biochemical oxygen demand (mg/ℓ) (BOD_5)	1.2	2.3	3.0	1.7	2.2	2.5	4.4	3.8	1.8	2.3	1.1	1.6	1.3	3.5	0.9	2.3	2.1	1.0	1.3	3.0	3.7
Velocity (ft/s)	<0.1**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.0	0.9	1.0	1.1	1.3	0.9	1.3	1.0	1.1	1.0	0.8	1.5	1.3	1.6
Conductivity (μmhos)	285	200	310	360	360	340	330	210	210	320	360	360	320	370	210	220	410	400	350	370	390

Parameter	Upper Town Creek							Lower Town Creek						
	1979			1980				1979			1980			
	Aug	Sep	Dec	Apr	May	Jun	Jul	Aug	Sep	Dec	Apr	May	Jun	Jul
BRECKINRIDGE SITE														
Dissolved oxygen (mg/ℓ)	5.9	6.3	6.6	11.2	10.1	7.2	8.9	7.7	6.5	6.6	13.0	9.1	10.8	8.0
Temperature (°C)	21.5	20.0	5.5	11.6	14.1	17.4	27.9	27.5	21.5	5.2	16.2	17.3	20.9	31.0
pH	5.4	7.1	5.1	6.1	5.6	6.3	6.8	5.8	7.2	5.3	5.9	5.7	6.6	7.1
Total dissolved solids (mg/ℓ)	209	262	238	286	303	297	212	211	178	151	225	236	223	137
Total suspended solids (mg/ℓ)	12	4	93	15	12	22	9	67	63	52	46	51	52	54
Turbidity (NTU)	27	22	69	–*	4	12	15	48	43	32	–*	5	43	50
Biochemical oxygen demand (mg/ℓ) (BOD_5)	3.1	2.2	3.3	1.2	1.7	2.2	3.3	4.6	3.0	3.1	4.5	3.9	3.6	4.3
Velocity (ft/s)	1.0	0.5	3.3	1.2	1.5	1.1	1.8	<0.1**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Conductivity (μmhos)	310	240	390	410	380	360	380	295	220	380	380	340	320	360

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*Samples held too long for analysis (delayed in transit).

**<0.1 = no measurable velocity.

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.4-18. Mean Length, Mean Weight, and Number of Fish Seined from Streams on the Hancock and Breckinridge Sites, 1979-1980

	August 1979								April 1980							
	Breckinridge Site				Hancock Site				Breckinridge Site				Hancock Site			
Taxon	Mean Length (mm)	Mean Weight (gm)	No.	Rel. Ab.	Mean Length (mm)	Mean Weight (gm)	No.	Rel. Ab.	Mean Length (mm)	Mean Weight (gm)	No.	Rel. Ab.	Mean Length (mm)	Mean Weight (gm)	No.	Rel. Ab.
Gizzard shad	92.5	8.6	2	1.0												
Grass pickerel	239.0	75.0	1	0.5												
Stoneroller	59.0	2.2	1	0.5	61.6	2.7	14	8.5	82.0	5.8	1	25.0				
Emerald shiner	40.0	0.7	4	2.1	91.0	5.6	2	1.2								
Striped shiner					61.0	2.6	3	1.8								
Shiner (U)									42.0	0.6	1	25.0				
Southern redbelly dace					60.1	2.1	42	25.6					53.0	1.6	1	33.3
Creek chub	37.3	29.0	24	12.7	64.8	5.0	61	37.2	49.0	1.3	1	25.0	55.5	2.0	2	66.7
Creek chubsucker					85.7	8.3	3	1.8								
Suckers (U)					58.1	2.1	7	4.3								
Blackstripe topminnow	56.0	1.6	1	0.5	56.0	1.7	1	0.6								
Mosquitofish	21.7	0.1	12	6.3	16.0	*	1	0.6								
Bluegill	50.9	10.6	126	66.7	55.6	8.0	11	6.7								
Longhear sunfish	109.5	25.0	2	1.0												
Lepomis spp.	40.0	1.0	1	0.5												
Largemouth bass					48.0	1.3	1	0.6								
White crappie	125.0	20.0	1	0.5					167.0	72.0	1	25.0				
Sunfish (U)	32.0	0.5	1	0.5												
Fantail darter	33.5	0.3	2	1.0												
Johnny darter	33.0	0.2	11	5.8	44.3	0.8	15	9.1								
Walleye	[illegible]00.0	50.0	1	0.5												
Freshwater drum					293.0	173.3	3	1.8								
Total No.			190				164				4				3	
No. of taxa			15				13				4				2	

	May 1980								June 1980							
	Breckinridge Site				Hancock Site				Breckingridge Site				Hancock Site			
Gizzard shad					182.7	63.3	3	17.6								
Stoneroller					91.0	10.0	1	5.9					78.7	5.8	18	15.6
Golden shiner	95.0	7.1	1	50.0					93.2	7.6	6	50.0				
Striped shiner													64.0	2.7	1	0.9
Shiner (U)									40.5	0.6	4	33.3				
Southern redbelly dace													58.7	2.2	14	12.2
Bluntnose minnow													41.0	0.7	1	0.9
Creek chub					64.7	3.7	11	64.7					68.7	4.3	72	62.6
Blackstripe topminnow													63.0	2.4	1	0.9
Bluegill	119.0	80.4	1	50.0	102.0	20.1	1	5.9								
Largemouth bass					93.0	9.9	1	5.9					105.0	14.4	1	0.9
Johnny darter													53.6	1.4	7	6.1
Total No.			2				17				12				115	
No. of taxa			2				5				3				8	

	July 1980							
	Breckinridge Site				Hancock Site			
Gizzard shad	163.7	70.3	3	21.4				
Stoneroller					66.9	4.3	9	5.2
Golden shiner					108.0	33.5	2	1.1
Southern redbelly dace	57.3	2.2	3	21.4	58.1	2.1	97	55.7
Creek chub	53.8	2.9	4	28.6	50.5	3.3	35	20.1
Minnows (U)					22.0	0.1	9	5.2
White sucker	43.0	0.8	1	7.1	56.6	4.9	8	4.6
Pirate perch					23.0	0.2	1	0.6
Green sunfish	126.0	47.2	1	7.1				
Johnny darter	59.0	1.9	2	14.3	48.1	1.2	12	6.0
Freshwater drum					209.0	141.0	1	0.6
Total No.			14				174	
No. of taxa			6				9	

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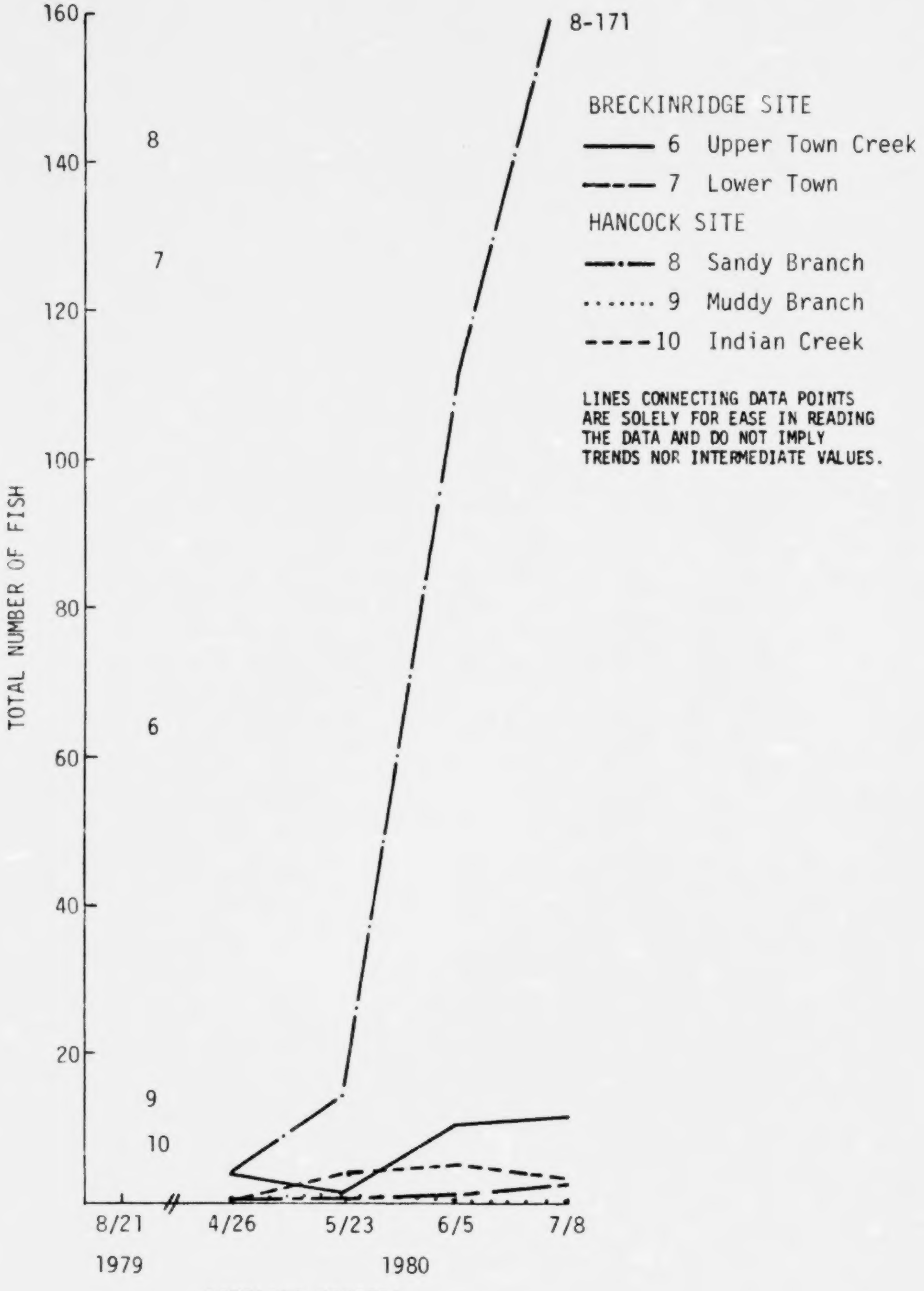
*1 specimen - no weight taken.

No. - catch per 2 seine hauls.
Rel. Ab. - percent of catch.
U - not identified to species.

Source: Texas Instruments Incorporated field data (1979-1980).



SOURCE: Texas Instruments (1980)

Figure 3.4-12. Numbers of Fish Seined from Onsite Streams 1979-1980

Table 3.4-19. Mean Density (per m^2) and Relative Abundance of Bottom Organisms in Streams on the Hancock and Breckinridge Sites, 1979-1980

	September 1979				December 1979				April 1980				July 1980			
	Breckinridge		Hancock		Breckinridge		Hancock		Breckinridge		Hancock		Breckinridge		Hancock	
Taxon	Mean Density	Rel. Abun.*	Mean Density	Rel. Abun.	Mean Density	Rel. Abun.	Mean Density	Rel. Abun.	Mean Density	Rel. Abun.	Mean Density	Rel. Abun.	Mean Density	Rel. Abun.	Mean Density	Rel. Abun.
Cnidaria																
Hydra spp.							21.7	1.2	21.7	0.3						
Platyhelminthes																
Turbellaria spp.			14.5	0.2	21.7	6.3							21.7	0.7		
Nemertina																
Nemertina (U)															14.5	0.6
Nematoda																
Nematoda (U)	108.7	0.8	43.5	0.6			43.5	2.5	21.7	0.3	43.5	2.1				
Oligochaeta																
Naididae (U)	2304.4	17.4					87.0	4.9	21.7	0.3	14.5	0.7	630.4	19.7	43.5	1.8
Tubificidae (U)	6804.3	51.3	594.2	8.4			902.2	51.2	1978.3	30.0	507.2	24.5	14565	45.6	1333.3	53.8
Branchiura sowerbyi									21.7	0.3			217.4	6.8		
Oligochaeta (U)					21.7	6.3										
Isopoda																
Asellidae (U)											478.3	23.1				
Asellus spp.											14.5	0.7			173.9	7.0
Lirceus spp.					173.9	50.0			21.7	0.3	29.0	1.4	21.7	0.7		
Gastropoda																
Gastropoda (U)	21.7	0.2														
Ferrissia spp.							21.7	1.2								
Amphipoda																
Pontoporeia affinis					21.7	6.3										
Hayalella azteca	21.7	0.2														
Gammarus spp.									108.7	1.6						
Decapoda																
Astacidae (U)	21.7	0.2														
Collembola																
Collembola (U)			29.0	0.4												
Ephemeroptera																
Leptophelebia spp.					43.5	2.5										
Hexagenia spp.			29.0	0.4												
Heptageniidae (U)									43.5	0.7						
Caenis spp.											29.0	1.4				
Ephemeroptera (U)			14.5	0.2					152.2	2.3						
Baetis spp.	21.7	0.2														
Baetidae (U)	217.4	1.6	87.0	1.2					130.4	2.0					14.5	0.6
Plecoptera																
Perlodidae (U)	21.7	0.2														
Amphinemura spp.									87.0	1.3						
Isoperla spp.									152.2	2.3						
Capnia spp.							21.7	1.2								
Plecoptera (U)					21.7	6.3	10.9	0.6	173.9	2.6	29.0	1.4				
Hemiptera																
Microvelia spp.	43.5	0.3														
Coleoptera																
Stenelmis spp.									152.2	2.3						
Dubiraphia spp.			14.5	0.2							14.5	0.7				
Elmidae (U)									43.5	0.7			87.0	2.7	14.5	0.6
Neuroptera																
Sialis spp.															14.5	0.6
Trichoptera																
Rhyacophilia spp.									21.7	0.3						
Cheumatopsyche spp.	1434.8	10.9	86.9	1.2	43.5	12.5			108.7	1.6			239.1	7.5	101.4	4.1
Hydropsychidae (U)	1130.4	8.5	144.9	2.1									195.6	6.1	29.0	1.2
Ochrotrichia spp.									43.5	0.7						
Polycentropus spp.															14.5	0.6
Leptoceridae (U)			14.5	0.2												
Trichoptera (U)															14.5	0.6
Diptera nematocera																
Tipulidae (U)															14.5	0.6
Ceratopogonidae (U)	173.9	1.3	14.5	0.2							72.5	3.5	21.7	0.7	14.5	0.6
Chironomus spp.									21.7	0.3						
Orthocladius spp.									587.0	8.9	29.0	1.4				
Cryptochironomus spp.			14.5	0.2					21.7	0.3	14.5	0.7	130.4	4.1	14.5	0.6
Monodiamesa spp.					43.5	12.5										
Cricoptopus spp.			58.0	0.8			21.7	1.2	130.4	2.0	43.5	2.1				
Tanytarus spp.	173.9	1.3	3927.5	55.8							58.0	2.8	43.5	1.4	101.4	4.1
Polypedilum spp.	434.8	3.3	869.6	12.3			21.7	1.2	1500.0	22.8	246.4	11.9	43.5	1.4	72.5	2.9
Ablabesmyia spp.	108.7	0.8	391.3	5.6			108.7	6.2			43.5	2.1			29.0	1.2
Microtendipes spp.	43.5	0.3					152.2	8.6	304.4	4.6			21.7	0.7	87.0	3.5
Paratendipes spp.			29.0	0.4							43.5	2.1				
Procladius spp.			29.0	0.4											29.0	1.2
Paracladopelma spp.			29.0	0.4												
Phaenopsectra spp.							43.5	2.5							43.5	1.8
Thienemanniella spp.			29.0	0.4					130.4	2.0	29.0	1.4			87.0	3.5
Micropsectra spp.									43.5	0.7	72.5	3.5				
Xenochironomus spp.							21.7	1.2					65.2	2.0		
Psectrocladius spp.	21.7	0.2													14.5	0.6
Endochironomus spp.	21.7	0.2	130.4	1.0												
Trichocladius spp.			29.0	0.4			21.7	1.2	391.3	5.9	72.5	3.5			72.5	2.9
Robackia spp.															43.5	1.8
Chironomidae (U)	65.3	0.5	395.8	5.7			65.2	3.7	152.2	2.3	188.4	9.1			72.5	2.9
Diptera brachycera																
Dolichopodidae (U)	21.7	0.2														
Diptera (U)	21.7	0.2	14.5	0.2			152.2	8.6								
Ectoprocta																
Ectoprocta (U)	21.7	0.2													14.5	0.6
Total Mean Density	13260.6		7033.6		347.7		1760.8		6586.9		2072.8		3195.4		2478.5	
Number of Taxa	23		25		7		17		28		21		14		25	

*Relative abundance = percent of mean density.

U = not identified to genus or species.

Source: Texas Instruments Incorporated field data (1979-1980).

far greater in late summer, when total mean density during the 1979-80 study was more than twice that of other sampling periods ($7034/m^2$ vs. 1761, 2073, and $2478/m^2$). Figure 3.4-13 shows total numbers of bottom organisms collected each sampling period in each stream.

Total mean density of macroinvertebrates in the water, including drifting benthos that is swept into the current, also appears greatest in late summer (Table 3.4-20). Midges are are consistently the dominant component of these organisms, although naidid worms, true bugs (Hemiptera), and isopods are abundant seasonally. The variety of macroinvertebrates inhabiting upper strata of the streams is considerably less than that of the bottom habitats (48 taxa of benthic macroorganisms, as indicated above, vs. 25 free swimming and drifting forms), as is the density. Figure 3.4-14 shows total numbers of free swimming and drift organisms collected each sampling period from each stream.

Although macroinvertebrate populations of the onsite streams are indicative of better water quality than that of the adjacent Ohio River, pollution-sensitive species are relatively uncommon, indicating less than excellent quality. Turbidity undoubtedly is high during heavy rainfall runoff, and agricultural pollutants (fertilizers, pesticides, and herbicides) probably wash and leach into the streams. Overall, the fauna are representative of typical Ohio River Valley alluvium streams and are indicative of generally good water quality.

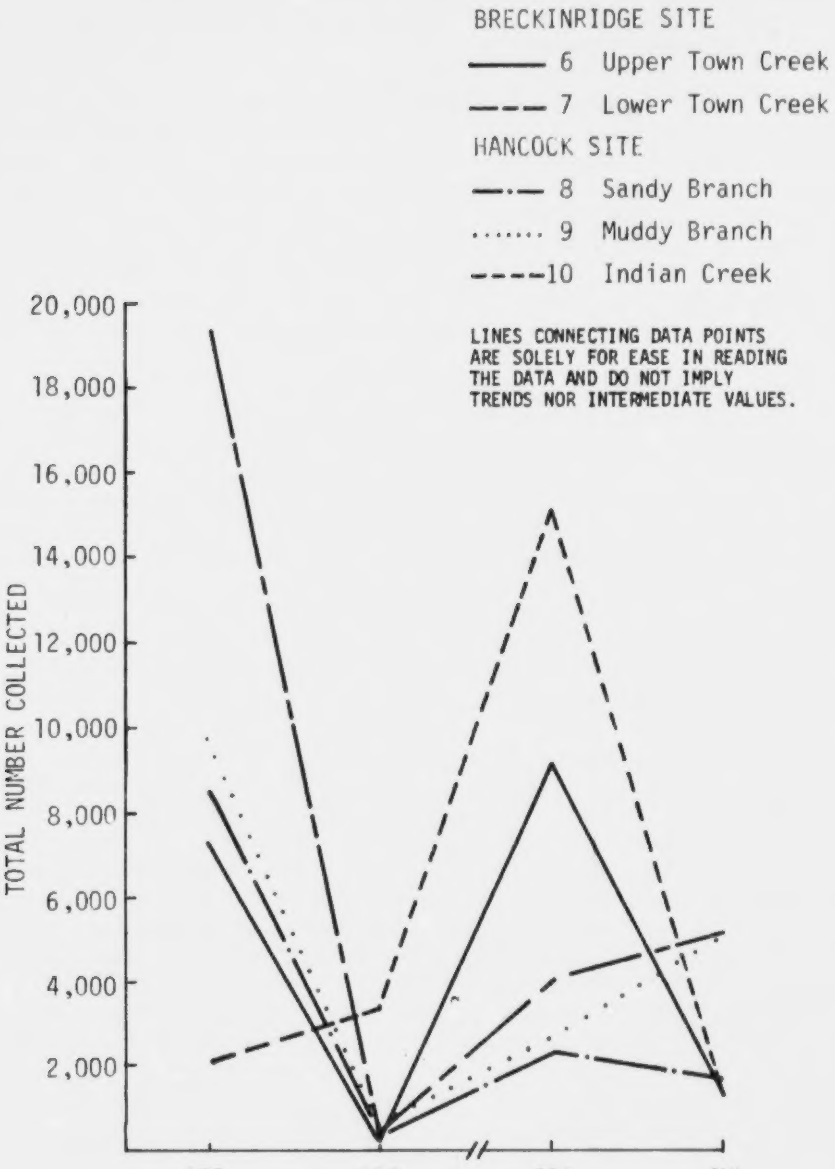
3.4.2.3 Hancock Site Groundwater

3.4.2.3.1 Aquifer Characteristics

Except in the higher elevations of the southern portion where bedrock is sandstone (Subsection 3.3.1.1.4), Glen Dean Limestone and Buffalo Wallow Limestone formations generally underlie the Hancock site. The Glen Dean Limestone occurs in the northern portion of the site at elevations of 300 to 350 feet msl (Table 3.4-21). This and other bedrock dips to the west under the site. The aquifer thickness above the Glen Dean Limestone varies from 50 to 150 feet, with the thicker portions along the northwestern part of the site. The aquifer above the Buffalo Wallow Limestone, which underlies lower elevations of the southern part of the site, varies from 15 to 40 feet in thickness. The alluvial aquifer at the site dips to the west, with a corresponding increase in thickness. Observed water table levels also decline to the west, indicating water movement in that direction.

3.4.2.3.2 Groundwater Quality

As in the case of other wells in the project area, some of those sampled on the Hancock site showed iron and nitrate levels that exceed EPA's (1976) recommended levels for drinking water (0.3 mg/liter and 10 mg/liter, respectively) (Table 3.4-22). Presence of these levels of nitrates (probably leachates from fertilizers) and iron (originating from bedrock) apparently has no detrimental health effects since two of the wells are used for human consumption. Other chemicals are within acceptable limits.



SOURCE: Texas Instruments (1980)

Figure 3.4-13. Numbers (per m^2) of Bottom Organisms Collected from Onsite Streams, 1979-7980

Table 3.4-20. Mean Density (per m^3) and Relative Abundance of Drift Organisms in Streams on the Hancock and Breckinridge Sites, 1979-1980

	September 1979				December 1979				April 1980				July 1980			
	Breckinridge		Hancock		Breckinridge		Hancock		Breckinridge		Hancock		Breckinridge		Hancock	
Taxon	Mean Density	Rel. Abun.*	Mean Density	Rel. Abun.	Mean Density	Rel. Abun.	Mean Density	Rel. Abun.	Mean Density	Rel. Abun.	Mean Density	Rel. Abun.	Mean Density	Rel. Abun.	Mean Density	Rel. Abun
Cnidaria																
Hydra spp.	5.9	0.2	36.1	7.0	0.8	0.5										
Platyhelminthes																
Turbellaria spp.							1.2	2.2					50.0	3.1		
Oligochaeta																
Tubificidae (U)	5.9	0.2					1.2	2.2	50.0	15.2						
Naididae (U)									41.7	12.7	33.3	16.1	750.0	46.8	66.7	62.5
Bivalvia																
Bivalvia (U)	5.9	0.2														
Isopoda																
Asellus spp.							2.5	4.3			67.7	32.3				
Lirceus spp.					52.4	32.3	2.5	4.3	20.8	6.3						
Amphipoda																
Gammarus spp.	5.9	0.2					3.7	6.5								
Gastropoda																
Physa spp.													50.0	3.1		
Arachnida																
Hydracarina													100.0	6.2		
Ostracoda																
Ostracoda (U)													300.0	18.7		
Collembola																
Collembola (U)	5.9	0.2	2.4	0.5									50	3.1	5.7	5.3
Folsomia spp.													4.7	0.3		
Ephemeroptera																
Baetidae (U)	172.6	5.6	7.3	1.4	21.5	13.3	8.6	15.2					9.3	0.6		
Cloeon spp.	47.6	1.5														
Heptageniidae (U)	5.9	0.2			0.8	0.5										
Stenonema spp.	5.9	0.2														
Choroterpes spp.	5.9	0.2														
Leptophlebia spp.					0.8	0.5	7.4	13.0								
Ephemeridae (U)	11.9	0.4			0.8	0.5										
Caenidae (U)													50.0	3.1		
Odonata																
Odonates (U)					0.8	0.5										
Plecoptera																
Capnia spp.					23.1	14.3	2.5	4.3								
Plecoptera (U)					1.6	1.0										
Hemiptera																
Trepobates spp.	450.0	14.6														
Microvelia spp.	17.9	0.6	62.5	12.1					20.8	6.3						
Rhagovelia spp.	550.0	17.8	66.7	12.9							26.7	12.9				
Hebrus spp.			2.4	0.5												
Hemiptera (U)	17.9	0.6														
Trichoptera																
Cheumatopsyche spp.	17.9	0.6											14.0	0.9		
Hydropsychidae (U)	5.9	0.2	2.4	0.5					20.8	6.3						
Trichoptera					0.8	0.5			20.8	6.3						
Lepidoptera microlepidoptera (U)									20.8	6.3						
Diptera nematocera																
Dixella spp.			10.4	2.0												
Tipulidae (U)	35.7	1.2														
Ceratopogonidae (U)													50.0	3.1		
Chaoborus spp.	5.9	0.2														
Culex spp.	5.9	0.2														
Anopheles spp.	35.7	1.2	23.3	4.5												
Culicidae (U)	17.9	0.6														
Cryptochironomus spp.													50.0	3.1		
Tanytarsus spp.	119.0	3.9	86.2	16.6									54.7	3.4		
Polypedilum spp.	898.8	29.1	184.8	35.6					62.5	19.0	66.7	32.3	18.7	1.2		
Cricotopus spp.					52.4	32.3										
Ablabesmyia spp.	410.7	13.3	7.3	1.4	0.8	0.5	16.1	28.3								
Corynoneura spp.	83.3	2.7														
Orthocladius spp.									20.8	6.3						
Thienemanniella spp.	23.8	0.8	7.3	1.4					50.0	15.2						
Trichocladius spp.	5.9	0.2			4.0	2.5	6.2	10.9								
Microtendipes spp.							1.2	2.2			13.3	6.5			33.3	31.2
Chironomidae (U)	101.2	3.3	14.6	2.8									50.0	3.1		
Simulium spp.	5.9	0.2			1.6	1.0	3.7	6.5								
Diptera brachycera																
Empididae (U)			4.9	0.9												
Total Mean Density	3089		518		162		57		329		207		1601		107	
Number of Taxa	30		15		14		12		10		5		15		3	

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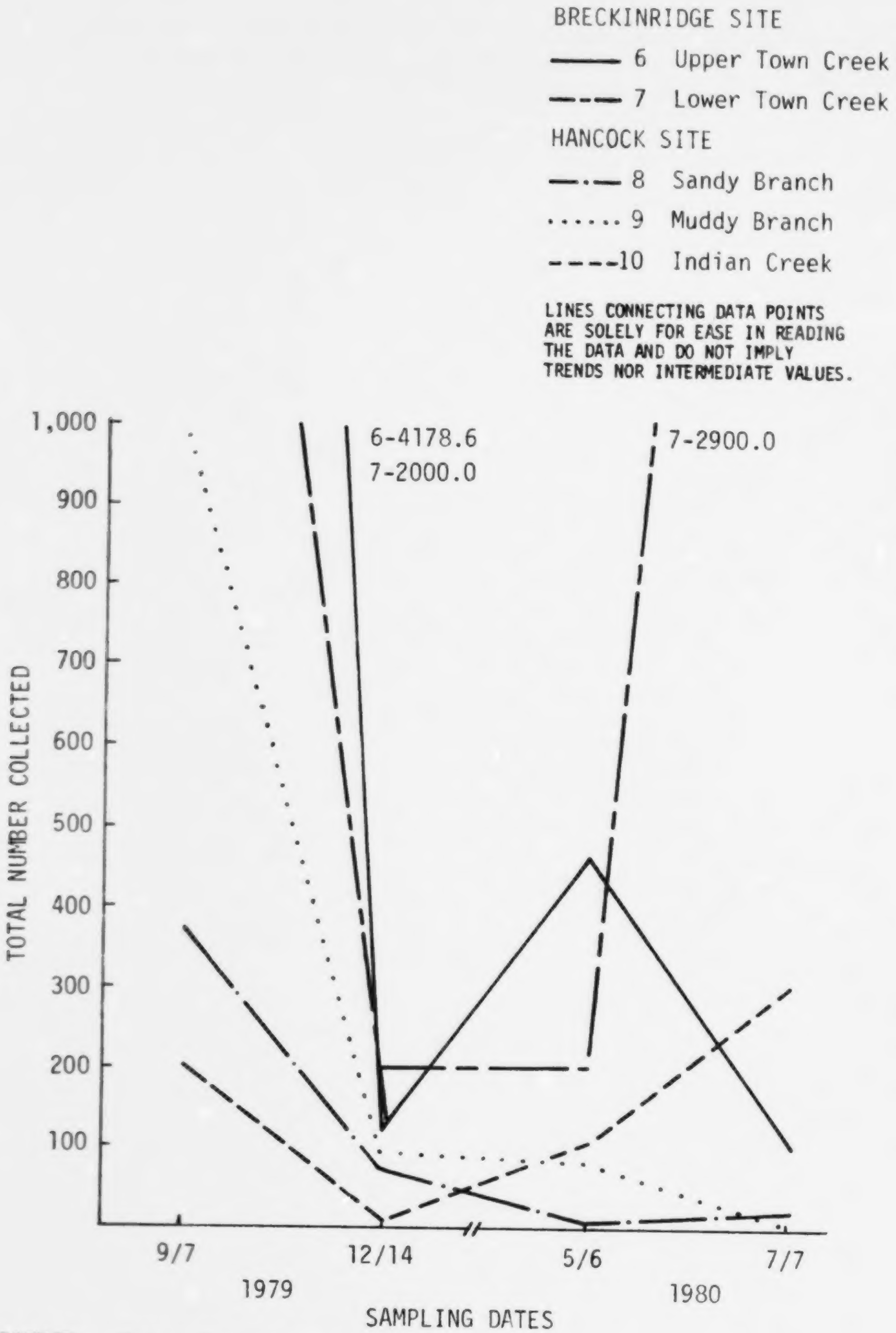
*Relative Abundance = percent of mean density.

U = not identified to genus or species.

Source: Texas Instruments Incorporated field data (1979-1980).



SOURCE: Texas Instruments (1980)

Figure 3.4-14. Numbers (per m^3) of Drift Organisms Collected From Onsite Streams, 1979-1980

Table 3.4-21. Aquifer Characteristics from Boring Data, Hancock Site, 1979

Borings					Bedrock		
		Location					
Number	Depth (feet)	UTM N	UTM E	Surface Elevation (feet msl)	Formation	Elevation (feet msl)	Depth to Bedrock (feet)
S-1	80.25	566,233.0	1,732,143.9	417.0	Glen Dean Limestone	347.5	69.5
S-2*	97.0	566,255.2	1,732,620.6	427.0	Glen Dean Limestone	340.7	86.3
S-3	79.5	566,454.9	1,733,499.8	424.8	Glen Dean Limestone	358.8	66.0
S-4*	63.5	567,788.0	1,733,708.0	419.4	Bedrock	356.9	62.5
S-5	69.0	567,934.3	1,732,868.0	415.9	Glen Dean Limestone	347.2	68.7
S-6	117.5	568,486.1	1,731,842.7	410.2	Top of rock	294.0	116.2
S-7	91.5	567,149.7	1,730,741.8	417.5	Glen Dean Limestone	328.0	89.5
S-8*	138.5	567,520.5	1,729,451.2	421.2	Shale	283.9	137.3
S-9	108.5	566,307.5	1,728,858.2	415.2	Glen Dean Limestone	308.2	107.0
S-10	56.2	565,406.5	1,728,858.3	429.3	Tar Springs Shale	372.9	52.0
S-11	89.5	567,459.8	1,738,760.2	397.4	Top of rock	308.4	89.0
S-12	31.0	564,754.9	1,735,436.0	505.5	Buffalo Wallow Shale	494.5	11.0
S-13	23.7	564,018.6	1,736,069.2	433.0	Tar Springs Shale and Siltstone	413.8	19.2
S-14	17.25	565,059.0	1,736,940.2	461.8		Auger refused	17.0
S-15	33.5	565,941.3	1,736,999.3	505.3	Buffalo Wallow Shale	488.3	17.0
S-16	20.5	567,345.0	1,736,755.4	464.2	Buffalo Wallow Shale	446.9	17.3
S-17	39.4	567,762.3	1,735,641.9	508.8	Buffalo Wallow Shale	471.3	37.5
S-18*	39.5	566,107.0	1,735,578.0	525.7	Buffalo Wallow Shale	489.2	36.5
S-19	20.0	565,981.8	1,734,864.0	485.2	Buffalo Wallow Shale and Siltstone	471.7	13.5
S-20	37.5	567,234.2	1,734,702.5	430.2	Top of rock	392.7	37.5
S-21*	40.0	566,791.2	1,734,184.4	459.3	Buffalo Wallow Shale and Siltstone	437.8	21.5

*Observed water levels (feet msl):

Date	S-2	S-8	S-18	S-21	C-1*
6-18-79	418.1	397.1	496.8	444.8	397.5
7-16-79	417.2	396.8	495.9	442.6	397.2
8-15-79	418.2	397.0	497.0	446.6	397.1
9-1-79	417.0	396.8	496.7	444.6	397.0
9-15-79	416.6	396.7	495.9	444.1	396.8
10-1-79	417.6	396.6	496.3	445.7	396.7
10-17-79	416.7	396.5	495.9	445.1	396.6
11-4-79	416.6	396.4	495.5	445.1	396.3

*COE piezometer adjacent to S-4

Figure 5.4-1 (Section 5.0) shows boring locations.

Source: Kentucky Utilities Company (1979).

Table 3.4-22. Summary of Analytical Data (mean mg/l) from Groundwater Samples, Hancock Site, 1979-1980[1]

Parameter	Well 1	Well 2	Well 3
Anions			
Bicarbonate ($CaCO_3$)	209	206	204
Carbonate ($CaCO_3$)	0	0	0
Chloride (Cl)	10	5.6	7.3
Fluoride (F), Total	0.21	0.09	0.18
Phosphorus (PO_4), Total	0.43[2]	0.06	1.58
Sulfate (SO_4)	19[2]	21	2.50
Nitrate (NO_3)	5[2]	13.8	0.2
Silica, Soluble (Si)	7.7	8.6	5.3
Cations			
Ammonia (N)	0.4[2]	0.25	[3]
Calcium (Ca)	62	58	54.0
Iron, Total (Fe)	1.6	0.22	18
Magnesium (Mg)	17	22	16
Manganese (Mn), Total	0.04	0.02[4]	0.33
Potassium (K)	0.8	3.8	0.9
Sodium (Na)	13	7.3	5.3
Total Trace Inorganics			
Aluminum (Al)	0.3	0.2	0.38
Antimony (Sb)	<0.005	<0.005	<0.005
Arsenic (As)	<0.005	<0.005	<0.050
Barium (Ba)	0.11[4]	<0.05	0.28
Cadmium (Cd)	<0.002	<0.002	0.002[4]
Chromium (Cr)	<0.005	<0.005	<0.005
Copper (Cu)	<0.060[2]	0.022[2]	0.006
Lead (Pb)	0.006[4]	<0.005	<0.005
Mercury (Hg) (μg/ℓ)	<0.02	0.012[2]	[5]
Nickel (Ni)	0.007[2]	0.003[2]	0.008[4]
Silver (Ag)	<0.002	<0.002	<0.005
Selenium (Se)	<0.005	<0.005	<0.005
Tin (Sn)	<2.0	<2.0	<2.0
Titanium (Ti)	<0.01	<0.05	<0.05
Vanadium (V)	<0.01	<0.02	<0.02
Zinc (Zn)	0.37	0.45	0.016
Other			
Bacteriological			
Total Plate Count (No./mℓ)	486[6]	7150[6]	25[6]
Fecal Coliform (No./mℓ)	<1	<1	<1
Carbon, Inorganic	53	55	57
Carbon, Organic	3[2]	4	3
pH	7.9-8.1	8.2	7.5-8.2
Solids, Dissolved	262	274	241
Solids, Suspended	8[2]	4[4]	22
Specific Conductance	469	477	425

Well 1 – Existing use: Ralph McIntyre property.
Well 2 – Existing Use: Shearn property.
Well 3 – KU Drilled 75 feet deep; not in use at present.

[1] Values represent average of samples collected 7/23/79, 3/12/80, and 5/21/80.

[2] One value below the minimum detection limit.

[3] Two values below 0.2 minimum detection limit; one value (5/21/80) at 6.1 mg/ℓ.

[4] Two values below the minimum detection limit.

[5] Two values below minimum detection limit (0.02 μg/ℓ); one value at 0.2 μg/ℓ.

[6] Bacteriological data for 7/23/79 not used in calculation, samples were held for approximately 3 weeks.

Source: Kentucky Utilities Company (1979-1980).

3.4.2.4 Hancock Transmission Corridor Streams

There are three streams along the Hancock transmission corridor: Indian Creek, Blackford Creek, and Sugarcamp Branch (see Figure 3.1-4). Water quality parameters observed in each stream are within Kentucky standards (Table 3.4-23 and Table 3.1-9). That part of Indian Creek in the transmission corridor has sandy/gravelly substrate, relatively small pools interconnected by narrow shallow riffles, and observed velocities of 1.6 and 0.9 feet/second. Like the lower reaches on the Hancock site, Upper Indian Creek has the potential for low dissolved oxygen during late summer and fall when decomposition of leaf litter and low velocities occur. Minnows and sunfish are among the fish fauna, and this fauna as well as the macroinvertebrate communities, probably are similar to those in lower Indian Creek. Unlike Blackford Creek and Sugarcamp Branch, farming is extensive in the Indian Creek watershed.

Blackford Creek, which parallels state highway 1700 where the transmission system likely would cross, is a small stream (observed width of 3 feet and depth of 4 inches) that apparently becomes intermittent during low rainfall periods. It has a sandy/gravelly substrate and observed velocities of 1.0 and 0.3 feet/second. No fish were observed, although presence of small species is likely, as is an extensive macrobenthic community.

Sugarcamp Branch is similar to Upper Indian Creek, with a sandy/gravelly substrate, small pools interconnected by narrow shallow (2- to 4-inch) riffles, and observed velocities of 1.2 and 0.7 feet/second. It has an extensive tree canopy and is subject to heavy leaf and litter fall. Fish observed include minnows and sunfish.

3.4.3 Breckinridge Site

3.4.3.1 Ohio River Miles 702-707

3.4.3.1.1 Fish

Fish populations in the Ohio River adjacent to Breckinridge site are similar to those downriver: forage fish, especially the gizzard shad and emerald shiner, are most numerous, rough fish are next most abundant, and commercial and game fish populations are comparatively small. Game fish present include the white bass, walleye, white crappie, sauger, smallmouth bass, and largemouth bass; commercial species include catfish and the freshwater drum.

Thirty-one species were collected from RM 705 to 707 during 1979-1980 (Tables 3.4-11, 3.4-12, 3.4-13). Three species previously unreported from the Cannelton Lock and Dam (Table 3.4-10) were collected: The log perch, mimic shiner, and bullhead minnow. A single river shiner, which is on the Kentucky Nature Preserves Commission Animal Element List was collected at RM 707.

3.4.3.1.2 Macroplankton and Macrobenthos

Fish Eggs and Larvae. Members of the herring family dominate this component of the macroplankton between RM 705 and 707, while minnows, suckers, and other forage and rough fish are present in large numbers (Table 3.4-24). As is the case downriver, eggs and larvae of the freshwater drum are abundant and apparently in greater proportion that the adults; game fish are uncommon;

Table 3.4-23. Water Quality of Streams Crossed by the Hancock and Breckinridge Transmission Corridors, 1980

	Hancock						Breckinridge					
	Blackford Creek		Sugarcamp Branch		Upper Indian Creek		Bull Creek		Clover Creek		Little Beach Fork of Clover Creek	
Parameter	May	July	May	July	May	July	May	July	May	July	May	July
Dissolved oxygen (mg/ℓ)	12.4	6.8	12.2	8.7	11.6	7.9	10.4	7.1	11.7	6.6	11.2	8.6
Temperature (°C)	12.8	20.6	12.9	17.5	12.1	18.5	13.0	20.0	13.2	21.0	11.8	20.5
pH	6.7	6.8	6.6	7.1	6.6	6.8	6.7	7.0	6.4	7.3	6.5	6.8
Total dissolved solids (mg/ℓ)	13	133	209	104	226	143	242	169	300	157	383	145
Total suspended solids (mg/ℓ)	123	17.2	1.5	4.6	8.0	104	19.5	80	11.5	36.8	2.5	44.4
Turbidity (NTU)	9	10	2	8	11	43	14	24	13	43	9	28
Velocity (ft/s)	1.0	0.3	1.2	0.7	1.5	0.8	0	0	0	0	1.0	0.7
Conductivity (μmhos)	180	235	300	195	345	320	305	270	290	145	390	220

Source: Texas Instruments Incorporated field data (1979-1980).

Table 3.4-24. Monthly Mean Numbers (per 100 m^3) of Fish Eggs and Larvae, Ohio River Miles 705 and 707, Breckinridge Site, 1979-1980

Taxon	RM 705						RM 707					
	1979			1980			1979			1980		
	Jun	Jul	Aug	Apr	May	Jun 4*	Jun	Jul	Aug	Apr	May	Jun 4*
Eggs												
Fish (U)								0.50		0.08		
Emerald shiner	0.09											
Freshwater drum	4.24	3.44	0.18				5.82					
Larvae												
Fish (U)	4.58	1.33	0.08		0.41	0.36	7.66	1.79	0.17	0.26	0.59	
Paddlefish										0.24		
Gar spp.	0.18											
Shad spp.	1.55			0.17	0.10							
Skipjack herring	0.48	19.81					0.09	0.10				
Herring spp.	721.90	24.09		0.19	6.52	1.86	425.52	12.15		0.10	3.57	
Mooneye					0.10		0.10					
Carp	12.36	7.94		0.09	50.95	0.73	4.15	1.84			4.35	
Emerald shiner	47.32	2.83	0.08		0.73	1.10	58.35	0.22			1.16	1.05
Minnows and shiners	0.53	0.58			0.30		0.09	0.19	0.10		0.19	0.35
Sucker spp.	20.91	4.94		14.49	6.22	7.71	32.86	5.26	0.19	26.52	5.03	1.06
White bass	0.38			0.27			0.67	14.82		0.33		0.36
Lepomis spp.	3.78	0.31					5.73					
Pomoxis spp.	1.39						0.37					
Sunfish spp.	3.67											
Sauger				0.18						0.08		
Freshwater drum	105.01	31.44	0.87		0.79	0.73	45.91	14.82	0.50		1.99	0.36

*Represents one sampling date; all other sampling periods represent 4 sampling dates.

Collection made with 0.5-meter hoop net (505-μm mesh).

U = unidentified.

Source: Texas Instruments Incorporated field Data (1979-1980).

and paddlefish are rare (a single catch at RM 707 of this Kentucky listed species). Maximum density seems to be in June. During the high-density period, distribution of taxa and numbers appears to be somewhat similar from near shore to mid-river and from surface to bottom (transect data on file at EPA Region IV). Greater variability in spatial distribution occurs during low-density periods.

Macrozooplankton. Common to abundant macrozooplankton in this section of the river include cladocerans, copepods, and amphipods (Table 3.4-25). Peak densities of copepods occur during spring and cladocerans are most abundant during summer, as is the case downriver. Amphipod abundances are consistent through spring and summer. A June peak of oligochaetes noted during the 1979-1980 study probably was due to the net dragging during sampling. Greatest overall density appears to occur in June with the second greatest numbers occurring in August (Figure 3.4-10).

Macrobenthos. As shown in Table 3.4-16, macrobenthic communities in the Breckinridge section of the river are similar to those at the Hancock site: tubificid worms predominate, midges are abundant, and these and most of the other benthos are pollution-tolerant or facultative. Overall densities appear greatest in winter and spring (Figure 3.4-11).

3.4.3.2 Breckinridge Site Stream

Town Creek is a permanent stream that begins as a small creek. Substrate of upper Town Creek is sandstone and limestone rubble and bedrock. The extent of groundwater contribution to the upper stream is not known, but steady flows observed in August and September indicate it may be significant. Observed velocities in the upper stream ranged from 0.5 feet/second to 3.3 feet/second (Table 3.4-17).

As Town Creek flows toward the Ohio River, it collects runoff from croplands and pastures. The lower reaches are sluggish (no measureable velocity), and substrates are silt, detritus, and sand. A sand bar, often above water, is a permanent feature of the mouth of Town Creek. At high level, water moves freely over the bar. During moderate and low water when there is no movement over the bar, considerable seepage might be expected.

3.4.3.2.1 Water Quality

Town Creek apparently has generally good water quality and no major pollution problems (Table 3.4-17). Values of the parameters analyzed during the 1979-1980 onsite study are within state standards except for pH, which was below the standard (6) during four of seven sampling periods. Total dissolved solids levels apparently are higher in upper Town Creek than in the lower part but are still within the range expected for small Kentucky streams (Minckley 1963; Neff and Krumholtz 1973).

3.4.3.2.2 Fish

At least 20 species of fish occur in Town Creek, including representatives of the perch, minnow, pike, herring/shad, topminnow, sucker, and sunfish families (Table 3.4-18). Overall, minnows and shiners makeup the majority of the fish present, although seasonally other species may be quite abundant (as

Table 3.4-25. Mean Numbers (per $100m^3$) of Macrozooplankton, Ohio River Miles 705 and 707, Breckinridge Site, 1979-1980

	RM 705					RM 707				
	1979			1980		1979			1980	
Taxon	Jun	Jul	Aug	Apr	May	Jun	Jul	Aug	Apr	May
Cnidaria										
Hydra spp.	6.95	0.98	24.82			0.28	3.38	8.19		0.34
Cordylophora lacustris					1.88					1.50
Nematoda										
Nematode (U)	0.42	0.25				17.39	0.27			
Oligochaeta										
Chaetogaster spp.									0.35	
Naididae (U)	0.42	0.26		5.21	47.98	11.45			2.20	13.15
Tubificidae (U)		16.31								
Gastropoda										
Gastropoda (U)		0.25								
Bivalvia										
Bivalvia (U)		0.25		0.65			0.30			0.32
Arachnida										
Hydracarina spp.	0.42	0.25				0.92				
Cladocera										
Bosminidae (U)	0.24					0.90				
Eurycercus lamellatus						0.64				
Daphnia galeata mendotae	1.23	1.85				0.27	0.96	0.30		
D. retrocurva	0.28		4.44					2.81		
D. pulex	27.75	1.01		2.51	2.47	58.50	0.29		3.81	2.08
D. parvula	46.35	52.30	40.25	0.91	2.80	63.94	13.22	42.91	0.67	2.13
D. spp.	3.91	0.50	0.99		2.33	2.34	1.23			
Simocephalus spp.	3.67	0.24		1.26		5.82	1.64		0.32	
Ceriodaphnia spp.	0.66	0.51				0.30				
Scapholeberis spp.				0.34		0.28				
Moinadaphnia spp.					0.36					0.36
Moina spp.	0.62	1.57	35.49			0.64	0.63	19.78		
Leptodora kindtii	0.38	2.29	0.30		0.38	0.28	0.55			0.36
Ilyocryptus sordidus						0.60				
Sida crystallina	3.49	0.78	4.35		0.36	10.47	0.90	4.01		0.36
Diaphanosoma spp.		3.14	4.57					3.30		
Cladocera							0.66			
Copepoda										
Diaptomus oregonensis	1.94	1.05				8.37				
D. siciloides	3.80			0.66	2.82	3.32		0.30		1.04
D. birgei	0.24			0.31		1.24				
D. pallidus			0.27		0.43					0.11
D. spp.		4.40	1.45	1.67	6.34	0.30		0.97	1.28	6.59
Osphranticum labronectum									0.30	
Calanoida (U)	2.11	3.87			6.71	0.28	0.37			
Cyclops vernalis	0.38		1.01	3.46	2.95	0.91			2.28	1.88
C. bicuspidatus thomasi									0.35	
Macrocyclops albidus	2.51					0.30	0.29		0.64	
Mesocyclops edax	16.24	0.27	0.37		0.43	5.48	0.29	0.64	0.32	
Cyclopoida (U)	1.14			0.62	0.86	0.64				0.71
Branchiura										
Argulus spp.	1.23					3.94				
Isopoda										
Asellus spp.					0.27					
Amphipoda										
Gammaridae (U)	6.82	4.70			6.73	10.33	18.69	0.67	5.76	9.96
Amphipoda (U)	1.50						0.33			
Collembola										
Ephemeroptera										
Heptageniidae (U)	0.71	0.99	1.06	0.35	0.36	0.58	3.63	0.34	2.60	0.80
Caenidae (U)		0.75	0.30	0.29			0.70	1.01		
Ephemeroptera (U)				0.61	0.27		1.53		0.64	0.41
Trichoptera										
Hydropsychidae (U)	0.80	1.29	2.09	0.60		1.45	0.66	4.24	5.47	0.74
Trichoptera (U)		0.54	1.24	0.72			0.27			0.34
Diptera										
Diptera nematocera	14.87	5.13				8.22	7.71			
Chaoborus spp.	0.52	4.62	0.95			1.42	4.35			
Chironomus spp.						0.30				0.34
Pentaneura spp.						3.30				
Chironomidae (U)	14.34	0.51	0.74		2.64	3.21	3.36	0.30	0.71	2.56
Diptera (U)		2.23	1.42					1.01	0.30	
Ectoprocta										
Ectoprocta (U)							0.37			

U = not identified to genus or species.

Source. Texas Instruments Incorporated field data (1979-1980).

indicated by a single large catch of bluegill during August 1979). As on the Hancock site, lower water levels of late summer probably concentrate fish populations, while higher waters of spring disperse them. Bank fishing is common on lower Town Creek at the embayment, although game fish appear limited in variety and number. Figure 3.4-12 shows numbers of fish collected in upper and lower Town Creek each sampling period.

3.4.3.2.3 Macroinvertebrates

Notable differences in the benthic macroinvertebrate community of Town Creek and those of the Hancock site streams are the greater overall density in Town Creek and a greater variety of pollution-sensitive species (Table 3.4-19). As might be expected, within Town Creek the most diverse component of the community occurs in the upper reaches where substrate and other habitats are more diverse. As on the Hancock site, total mean benthos density appears greatest in late summer (13,260/m^2 collected in September vs. 348/m^2, 6587/m^2 and 3195/m^2 during December, April, and July, respectively). Midges and oligochaetes are predominant in the community, with caddisflies abundant in late summer. Figure 3.4-13 shows total numbers of bottom organisms collected form each part of Town Creek during each sampling period.

Total mean density of free swimming and drifting macroinvertebrates also is greater in Town Creek than in the Hancock site streams (Table 3.4-20). The number of taxa also appears greater (39 identified from Town Creek vs. 25 identified from the Hancock site streams), with greater mayfly and midge diversity the primary difference. Figure 3.4-14 shows total numbers of free swimming and drift organisms collected from each part of the stream each sampling period.

Although many pollution-tolerant and facultative species are among the Town Creek macroinvertebrates, overall good water quality is indicated by the comparatively large numbers of pollution-sensitive mayflies and midges as well as comparatively diverse stonefly and caddisfly components. A primary factor in the status of Town Creek is that cultivation and agricultural pollutants are limited in the upper watershed.

3.4.3.3 Breckinridge Site Groundwater

3.4.3.3.1 Aquifer Characteristics

Much of the bedrock underlying the Breckinridge site is Hardinsburg Sandstone (Subsection 3.3.1.1.5), which dips to the west and northwest beneath the alluvial aquifer. Elevation of the Hardinsburg Sandstone varies from 270 to 340 feet msl (Table 3.4-26). The thickness of the alluvium above bedrock varies from 100 to 150 feet. The observed water table levels show a definite decline to the west and northwest, indicating movement of water in those directions.

3.4.3.3.2 Groundwater Quality

No groundwater quality samples have been taken on the Breckinridge site. Indications are that nitrate and iron levels would be as high as elsewhere in the study area, including the Indiana side. Otherwise, there should be no groundwater pollution problems on the site.

Table 3.4-26. Aquifer Characteristics from Boring Data, Breckinridge Site, 1979

Borings					Hardinsburg Sandstone	
Number	Depth (feet)	Location		Surface Elevation (feet msl)	Elevation (feet msl)	Depth to Bedrock (feet)
		UTM N	UTM E			
S-1*	111.0	576,656.3	1,762,771.0	429.4	323.4	106
S-2*	136.75	573,160.3	1,761,593.0	434.2	309.7	124.5
S-3	75.0	Not Permitted Access		–	–	–
S-4*	98.5	572,815.0	1,763,082.1	432.7	337.2	95.5
S-5	117.0	574,308.3	1,761,677.3	426.4	313.4	113.0
S-6	94.0	576,356.3	1,762,771.0	428.1	335.6	92.5
S-7	125.0	574,745.0	1,761,072.7	420.8	305.3	115.5
S-8*	120.0	575,313.7	1,760,220.5	422.2	308.2	114.0
S-9	55.0	574,190.5	1,759,126.8	420.3	–	–
S-10	151.5	571,475.3	1,757,915.1	422.0	271.0	151.0

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* Observed water levels (feet msl):

Date	S-1	S-2	S-4	C-2*
6-18-79	409.4	405.7	426.1	–
7-16-79	404.1	405.1	423.9	385.3
8-15-79	404.4	405.1	425.6	385.5
9-1-79	404.1	404.9	424.1	385.6
9-15-79	403.8	404.7	423.7	385.1
10-1-79	403.8	404.7	426.1	386.4
10-17-79	403.4	404.5	425.3	385.8
11-4-79	403.1	404.5	425.0	385.1

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* COE piezometer adjacent to S-8

Figure 5.4-2 (Section 5.0) shows boring locations.

Source: Kentucky Utilities Company (1979).

3.4.3.4 Breckinridge Transmission Corridor Streams

Streams along the path of the Breckinridge transmission corridor are Bull Creek, Clover Creek, and Little Beach Fork of Clover Creek (Figure 3.1-5). Water quality parameters observed in each stream are within Kentucky standards (Table 3.4-23 and Table 1.3-9). Bull Creek in the area potentially crossed by the transmission system is relatively large and pond-like with no measurable velocity and silty/muddy bottom. Both fish and benthic populations probably are like those in similar habitats in lower Town Creek.

Clover Creek is the largest of the three streams along the corridor (observed width of 30 feet and depth of 6 to 7 feet). Where the transmisison system could cross, the substrate is silty/muddy and velocity is too slow to measure. It also likely supports faunal groups similar to those of lower Town Creek.

Little Beach Fork of Clover Creek is located primarily in upland hardwoods and areas of rather significant relief. It has gravel, rubble, and sand substrate; is moderately large (observed width of about 12 feet and depth of 1 to 2 feet); and has riffles and pools with observed stream velocities of 1.0 and 0.7 feet/second. It undoubtedly supports more diverse benthic fauna than Clover and Bull creeks, partly because sediment accumulation is less than exhibited in the other streams. Like the others, it could undergo periods of low oxygen concentration as a result of low velocity and/or accumulation of decomposable materials.

3.4.4 Elizabethtown Transmission Corridor Aquatic Resources

From the proposed tie-in point south of the Hancock site, the Elizabethtown corridor crosses 18 waterbodies - 17 streams and 1 pond/marsh complex. One of the streams, Clover Creek, is crossed at 5 points. Within the corridor at all stream crossings, virtually all tree canopy has been removed. Significant herbicide-related stress is present among riparian vegetation and streamside mosses and lichens inside and adjacent to the corridor at the Tar Fork of Clover Creek and Clover Creek crossings.

The largest stream crossing is Tar Fork of Clover Creek. This drainage and those of Clover Creek and the Rough River are the most extensive watersheds crossed by the corridor. Each of the stream crossings that is south of the sites is similar to most of the streams previously described, with silty/sandy substrate and little to no measurable flow. Most crossings east of the potential Breckinridge corridor exhibit greater flow and sandy/bedrock substrates. Erosion is noticeable on most streams but is greatest where livestock occur. Siltation is not a problem in the faster streams. Table 3.4-27 summarizes characteristics of those streams with permanent flow. None of the stream crossings will require a Department of Army (404) permit.

Faunal populations in streams along the Elizabethtown corridor likely are comparable to those in similar habitats on the sites. Streams with silty/sandy bottoms probably have macrobenthic communities comprising mostly pollution-tolerant and facultative species and those with sand, gravel, and rubble substrates support a greater variety and abundance of pollution-sensitive species and a more diverse macrobenthic community in general. The larger streams exhibit habitat suitable for gamefish. There are no records of Federally designated threatened and endangered aquatic species in the corridor nor are any species on the Kentucky Nature Preserves Commission Animal Element List known to occur there.

Table 3.4-27. Characteristics[1] of Waterbodies Crossed by Elizabethtown Corridor, July 1980

Waterbodies	Depth (feet)	Width (feet)	Stream Bed Width (feet)	Flow (ft/sec)	Clarity	Bottom	Edge	Cover Type	Wildlife	
									Aquatic	Terrestrial
Tar Fork Tributary	No water	No water	3	–	–	Silt/sand	Herbs	Fallow	Poor	Fair
Tar Fork Creek	6	90	–	0.1	Moderate	Silt/sand	Herbs/shrubs	Old field	Good	Good
Clover Creek	0.5 to 7	4 to 30	–	–	Moderate	Silt/sand	Herbs/shrubs	Fallow/old field	Good	Good
Bushlick Branch	0.3	2	4	–	Clear	Silt	Herbs	Fallow	Fair	Fair
Hardins Creek	0.3	2	4	0.1	Moderate	Limestone	Herbs	Fallow	Fair	Good
Tules Creek	No water	No water	2	–	–	Grassy	Herbs	Fallow	Poor	Fair
Fiddlers Creek	0.3	2	6	0.3	Clear	Sand/bedrock	Herbs/shrubs	Fallow	Fair	Good
Vertrees Creek	0.7	18-20	–	0.6	Moderate	Sand/gravel	Herbs/shrubs	Fallow	Good	Good
Rough River	3	30	–	1.1	Turbid	Sand/bedrock	Herbs/shrubs	Fallow	Good	Good
Hicks Lake (Wetland)	3	7 acres	–	–	Clear	Silt	Herbs	Fallow	Good	Fair
West Rhudes Creek	0.7	4	–	0.6	Turbid	Sand/bedrock	Herbs	Fallow	Poor	Poor
Valley Creek	1.5	4	6	0.6	Turbid	Sand/bedrock	Herbs	Fallow	Fair	Fair

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[1] All measurements approximate.

Source: Texas Instruments Incorporated field data (1980).

4.0 IMPACT ASSESSMENT

The effects of the proposed generating station and transmission system on the human, biological, and physical environments of the project area are presented in a manner that parallels, to the extent practical, the description of the environments. Thus, each section -- 4.1 HUMAN FACTORS, 4.2 ATMOSPHERE, 4.3 LAND, 4.4 WATER -- is divided into subsections that define environmental elements. Each subsection first describes those impacts that will be regional or project-area wide, or those that are generic to power plant and transmission development. This is followed by descriptions of the salient differences between development of the project on the Hancock site and development on the Breckinridge site. The description of the effects of each alternative generally is organized to show impacts of the generating station and each transmission system, Unit 1 (the southward corridor from each site) and Unit 2 (the existing Elizabethtown transmission corridor). Where applicable, the effects of construction and operation of the generating station are distinctly separated; also where appropriate, the effects of generating station and transmission development are treated as project effects.

Assumptions used for impact assessment are described in the text rather than in an assessment methodology section to facilitate extension of the assumptions to the impact. It often is assumed that effects on certain environmental elements will be the same regardless of which site is developed. This assumption applies only to the level of detail that is known or, in some instances, appropriate.

As indicated in Sections 2.0 and 3.0, levels of information pertinent to the Breckinridge site are not always equal to those for the Hancock site. Site development plans have not been pursued to the same extent, and project-related surveys of groundwater quality and archaeological resources, especially, have either not been done or are incomplete, precluding precise comparison. The USDA Soil Conservation Service survey of soil characteristics also is incomplete on the Breckinridge site.

Nevertheless, most of the salient effects of the project can be estimated, and with the exception of onsite surface water resources and background noise levels, resources and values associated with the Hancock site apparently will receive greater adverse impact. Further, the project-related benefits to economic and social structure are estimated to have greater positive impact on Breckinridge County than on Hancock County.

Siting of Ashland Oil's proposed synfuel plant adjacent to Kentucky Utilities' Breckinridge site is still uncertain but apparently is a preferred alternative at present. The Commonwealth of Kentucky has secured a purchase option on the land, environmental assessment activities have occurred on the site, and a scope of work for the EIS program is being developed. Reference to the project is made where appropriate in this impact assessment, with cumulative effects of the two projects addressed where possible. Should proposed development actually occur adjacent to the Breckinridge site, it supposedly would begin before KU's project and would impact Town Creek and existing rural noise levels. It also would diminish beneficial impacts attributable to KU.

Indications are that the human environment would be significantly impacted by simultaneous development of the two projects. Further, many of these cumulative impacts will occur regardless of which site is developed for the power plant. Construction of the synfuel plant, for example, apparently will require a peak work force of nearly 5000 workers, and operation of the plant would employ more than 1000 workers. Most of these workers will come from the same laborshed projected for the Hancock project. Additionally, because many synfuel workers are expected to commute from Perry County, Indiana and other locations west of the Breckinridge site, the impacts associated with stressed highways, housing, police protection, etc., will be felt equally in Hancock County. Thus all adverse impacts associated with the synfuel plant will not be solely incremental to KU's Breckinridge site alternative.

In the following discussions of impact of the Hancock Generating Station, the project region is considered to be the 17 Indiana and Kentucky counties that likely will contribute labor and goods and services to the project. The project area generally includes the three counties that surround both sites and the county in which much of the Elizabethtown corridor lies.

4.1 HUMAN FACTORS

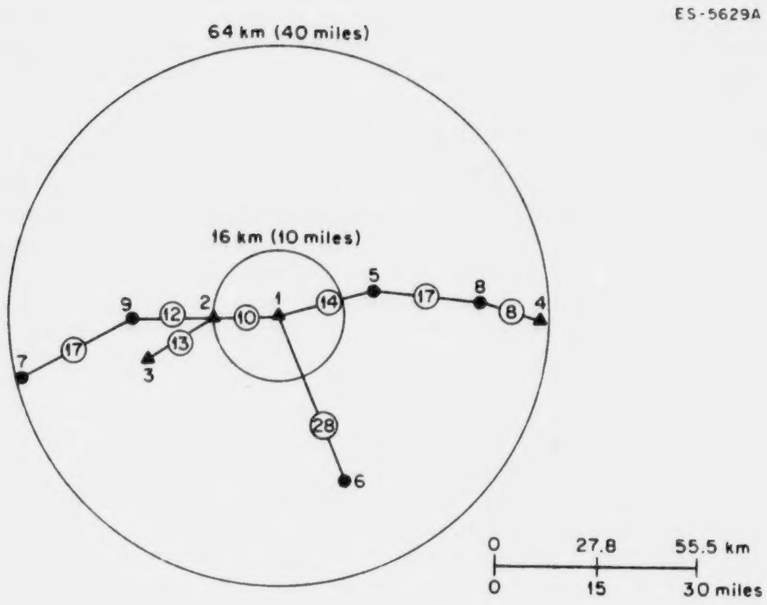
The proposed Hancock Generating Station project will affect all aspects of the area's human environment. Population in the project area will increase, leading to greater demand for housing, education, municipal services, and infrastructure. Traffic will increase on local highways resulting in greater need for traffic control and greater risk of accident. Demand for recreational opportunities will increase, land use patterns and area aesthetics and cultural resources will be altered, and the social composition of area communities will be somewhat different.

Because industrialization is ongoing in the lower Ohio River Valley, contractors, skilled labor, and materials necessary to support the Hancock project are available in the region. This means that construction of the proposed power plant and transmission system will not unduly strain the regional economy and socioeconomic infrastructure. However, the communities in the immediate vicinity of the Hancock and Breckinridge sites do not have services or facilities adequate to deal with a major population influx. Thus, many of the impacts to the human environment of the area will depend, in kind and magnitude, on the response of the regional labor force to the opportunity created by the project.

Labor force response is difficult to assess because of the marginal position of both sites relative to major regional population centers including Louisville, Kentucky and Evansville, Indiana. Owensboro, Kentucky, which cannot provide the total necessary labor force, is the closest population center to both sites and within about an hour commuting time to each. Commuting times from Evansville and Louisville will average no less than 1 1/2 to 2 hours because of the winding, mostly two-lane access to the project area (U.S. Highway 60) and periodic adverse weather conditions. Although increases in commuting costs and fluctuations in fuel availability may accelerate changes in commuting patterns in the 1980s, present conditions support the assumption that between 80 and 85% of the construction workforce will commute. Additional considerations in this assumption include the limited temporary housing facilities in the project area and the substantial expense of relocating for the relatively short period that most construction workers will be required.

Other assumptions used in evaluating impacts to the human environment were that about 17% of the construction work force will relocate to the project area temporarily, and they will reside in Perry County, Indiana and Hancock and Breckinridge counties, Kentucky; the operating workforce will comprise about 40% local hires and about 60% immigrants; the operating force will be permanent and will live in the project county (for a worst case and workable approach, although some of the projected 180 workers, local hires especially, will undoubtedly live in the other two counties); and each immigrant, temporary or permanent, will bring two dependents.

Adding greatly to the complexity of assessing impacts attributable to the Hancock project are the cumulative effects associated with other energy developments in the general area. Between the Breckinridge site and Evansville, Indiana (about 80 miles) are six proposed or approved projects (Figure 4.1-1) that will require nearly 12,000 workers in 1986 (Table 4.1-1). Further, there are three additional proposed projects within 30 miles west of Evansville which, if developed, will double the regional workforce demands during the Hancock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▲ **SYNFUEL FACILITIES**
1. SRC I
2. W. R. GRACE
3. TRI STATE
4. H-COAL

● **ELECTRICAL GENERATING PLANTS**
5. ROCKPORT
6. D. B. WILSON
7. GIBSON
8. HANCOCK
9. A. B. BROWN

CIRCLED NUMBERS CONNOTE
APPROXIMATE DISTANCE IN MILES

SOURCE: U.S. Department of Energy (1981)

Figure 4.1-1. Locations and Interplant Distances of Energy Related Projects Between the Breckinridge Site and Evansville, Indiana, 1981

project construction period. The significance of the Hancock project within this larger regional context is relatively small, except in peak construction years of the late 1980s (no comparable figures are available for 1990 through 1993). For this reason the focus of this impact assessment is on those counties (Hancock, Breckinridge, Hardin, Kentucky and Perry, Indiana) that will be directly affected by the proposed project and less directly affected by most of the others.

As mentioned, the project most likely to simultaneously impact the Hancock project area is the large H-Coal synfuel project proposed for the Breckinridge site area. This synfuel project will require a peak work force of 4700 (Table 4.1-1), or about five times that for the Hancock project. This will occur in 1986 when the Hancock project is expected to require about 600 workers, or about 10% of combined needs. During 1987 when the Hancock work force for Unit 1 is peaking, the H-Coal project will require more than 2000 workers, or about 70% of combined needs. Only in 1988 will the Hancock project require a greater proportion of workers (62%) than the H-Coal project because the H-Coal operational work force probably will be building up when Hancock Unit 2 will require another peak work force in 1992. The ultimate H-Coal operating work force will be eight times greater than Hancock's (1500 vs. 180).

Table 4.1-1. Competing Construction Labor Demands in Hancock Project Region, 1982-1989

	1982	1983	1984	1985	1986	1987	1988	1989
Projects between Breckinridge Site and Evansville, Indiana								
W.R. Grace	0	475	2,920	5,675	5,332	2,292	1,218	1,350
SRC-1	2,330	1,685	300	400	400	785	1,810	3,405
H-Coal	0	0	192	2,050	4,708	2,368	600	600
D.B. Wilson	1,100	950	725	360	250	250	250	250
Rockport	2,100	3,000	2,750	1,550	500	300	300	300
Hancock	21	41	174	340	598	920	981	161
Total	5,551	6,151	7,061	10,375	11,788	6,915	5,159	6,066
% Hancock	0.4	0.7	2.5	3.3	5.1	13.3	19.0	2.7
Total Hancock and H-Coal	21	41	366	2,390	5,306	3,288	1,581	761
% Hancock	100	100	47.5	14.2	11.3	28.0	62.0	21.2
Projects West of Evansville	375	960	4,175	11,450	14,565	7,735	3,045	3,300
Total Projects	5,926	7,111	11,236	21,825	26,353	14,650	8,204	9,366
% Hancock	0.4	0.6	1.5	1.6	2.3	6.3	12.0	8.1

Source: Figures for all but the Hancock project are averages of 4 quarterly figures from Appendix CC of the Solvent Refined Coal-1 DEIS. U.S. Department of Energy (1981).

Thus, social and economics impacts associated with the H-Coal project will precede those attributable to the Hancock project and, for the most part, will overshadow them and reduce their significance, especially from the perspective of the Breckinridge site alternative. It is expected that cumulative impacts of the two projects will be developed in greater depth in the forthcoming H-Coal DEIS. Until potential mitigation (e.g., widening of U.S. 60 in the project area) is more definitive, the relative significance of the Hancock project can be discussed only in general terms.

4.1.1 Population and Socioeconomic Conditions

Project-related population changes of sufficient magnitude to noticeably affect community infrastructure will occur only in the three counties surrounding the Hancock and Breckinridge sites. Unlike population changes, socioeconomic effects of the project will be more regional in nature since most of the work force is expected to commute and substantial materials and services are projected to be purchased from regional suppliers. No distinguishable changes in population or socioeconomic conditions are anticipated from transmission system development, so this discussion applies to the project as a whole.

4.1.1.1 General Effects on Population Size and Distribution

During the period 1982 through 1994, the Hancock project will increase population of the 3-county project area as much as 1.6% over current population (Table 4.1-2). The greatest increase will occur in 1992, when inmigrant construction workers and operating personnel and dependents are expected to be more than 700. Somewhat lesser increases will occur in 1987-88, associated with construction workers only, and in 1991 and 1993. After 1994, operation inmigrants will permanently increase current area population size by approximately 0.7%. It is expected that adequate numbers of potential workers are available in the three counties to provide an indirect work force sufficient to supply goods and services for the temporary and permanent inmigrants.

If the H-Coal project is considered and the same inmigration assumption (17.5% of the work force amd 2 dependents for each worker) is applied, the three counties will experience markedly greater population increases prior to the 1988 Hancock construction peak. In 1986 there will be 2,715 inmigrants associated with both projects for an increase of 6.2%; this will decline to 831 in 1988 for a cumulative increase of 1.9%. The H-Coal project's influx of 2400 construction workers and dependents in 1986 would account for a 5.5% population increase, which is more than three times greater than the maximum increase attributable to the generating station project. If the H-coal operations work force is considered and if a conservative one-third of these are inmigrants to the project area counties, the population increase would be twice that anticipated for the peak years of generating station construction and it would be permanent. Also, with both projects occuring, construction inmigration might be greater because of increased competition for available labor in the region and impacts would be greater. Likewise, the assumption (based on existing unemployment) that sufficient indirect workers would be available to support the increased population probably would not be viable with both projects underway, necessitating even more inmigration to the area.

Table 4.1-2. Temporary and Permanent Inmigrants Expected for Hancock Generating Station

Year	Workers	Workers and Dependents	Percent Increase over 1980 3-County Population
1982	4	12	0
1983	7	21	0
1984	30	90	0.2
1985	60	180	0.4
1986	105	315	0.7
1987	161	483	1.1
1988	172	516	1.2
1989*	106	318	0.7
1990*	103	309	0.7
1991*	153	459	1.1
1992	238	714	1.6
1993	170	510	1.2
1994	89	267	0.6
Operation	108	324	0.7

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*Includes operation inmigrants.

Because of its size, reasonable access to the sites, and number of amenities, Tell City, Indiana probably will attract a significant number of construction inmigrants. Assuming that 40% of the Hancock project construction inmigrants will live in Perry County, 40% will live in the county in which construction occurs, 20% will live in the adjacent county, and all operation inmigrants will relocate in the project county, potential distribution of the inmigrant population is shown in Table 4.1-3.

The estimates of population changes attributable to construction of the generating station, although assumptions, provide a benchmark for estimating other impacts within the project area. Depending on the site of construction, county population can be increased temporarily as much as 5.5% over 1980 population. The increases will be greater if the amount of commuting is less than anticipated.

4.1.1.1.1 Hancock Site Alternative

Development of the generating station in Hancock County will result in a maximum population increase over 1980 level in that county of about 5.5% by 1992 (Table 4.1-3). This will level off to an approximately 4% increase that will be due to operation inmigration. Projected population increase in the county without the project is less than 6% from 1980 to 1990. This is less than expected for Kentucky as a whole and reflects the substantial outmigration characteristic of the area for many years. One possible secondary effect of the influx of new population with the project is a slowed outmigration and a greater overall rate of population growth for the county.

Table 4.1-3. Distribution of Inmigrant Population Expected for the Hancock Generating Station, Inmigrant Population, and Percent Increase over 1980 Population

	Either Alternative	Hancock Alternative		Breckinridge Alternative	
Year	Perry County	Hancock County	Breckinridge County	Hancock County	Breckinridge County
1982	5(0.0)	5(0.0)	2(0.0)	2(0.0)	5(0.0)
1983	9(0.0)	9(0.1)	3(0.0)	3(0.0)	9(0.0)
1984	36(0.2)	36(0.5)	18(0.1)	18(0.2)	36(0.2)
1985	72(0.4)	72(0.9)	36(0.2)	36(0.5)	72(0.4)
1986	131(0.7)	131(1.7)	53(0.3)	53(0.7)	131(0.8)
1987	201(1.1)	201(2.6)	81(0.5)	81(1.1)	201(1.2)
1988	214(1.1)	214(2.8)	86(0.5)	86(1.1)	214(1.3)
1989*	86(0.5)	188(2.4)	44(0.3)	44(0.6)	188(1.1)
1990*	83(0.4)	182(2.4)	43(0.3)	43(0.6)	182(1.1)
1991*	124(0.7)	271(3.5)	64(0.4)	64(0.8)	271(1.6)
1992	193(1.0)	421(5.5)	100(0.6)	100(1.3)	421(2.5)
1993	138(0.7)	301(3.9)	71(0.4)	71(0.9)	301(1.8)
1994	72(0.4)	158(2.0)	37(0.2)	37(0.5)	158(0.9)
Operation		324(4.2)			324(1.9)

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*Includes operation inmigrants.

Greatest concentration of new residents in Hancock County probably will be in locations west of the site from Hawesville to Lewisport, where purchase and rental housing, services, and amenities are most readily available. Residential concentrations in Perry and Breckinridge counties will be primarily near Tell City and Cloverport, respectively.

Approximately 12 families will be relocated from the Hancock site and a few others adjacent to the site may leave because of increased activity on the site and/or the presence of the plant. Those families owning small acreages and deriving most of their income from nonagricultural jobs probably will relocate in Hancock County, while those engaged in farming may purchase land outside the county.

4.1.1.1.2 Breckinridge Site Alternative

Because of greater population, the effect of the project on Breckinridge County population as a whole will be approximately one-half that experienced in Hancock County. However, location of the plant in the northwestern corner of the county and the assumed desire of inmigrants to live relatively near their work probably will concentrate new residents in the Cloverport area rather than near Hardinsburg, which is the largest urban area in the county. In this case, as in the Hawesville area, the incremental effect of 200 to 300 new residents during peak construction would be significant, representing nearly a 25% increase in area population.

Other effects of population changes also will be similar to those discussed for the Hancock County location of the project. Approximately 10 families will be relocated, and others may choose to move.

4.1.1.2 General Effects on Socioeconomic Conditions

Like population changes, project-related socioeconomic effects will be most pronounced during the construction phase. With most of the construction work force expected to commute, income derived from the project will be dispersed into locations up to 80 miles away. These same locations (Louisville, Evansville, and Owensboro) are expected to provide much of the materials and services projected to be purchased locally during construction of the generating station and transmission system. The direct and indirect economic effects will be greatest from 1987 to 1988 and from 1991 to 1993 and will continue at much lower levels throughout the life of the project. The 3-year hiatus between peak economic benefits could be a distinct disadvantage to project-area suppliers that increase their inventories and/or space, and business losses during that time could affect their willingness to prepare for the second peak.

4.1.1.2.1 General Effects on Regional Employment and Income

Maximum direct employment for the project will be during 1992, with a total of 1046 jobs and direct salaries and wages of $83.9 million (see Tables 1.3-2 and 1.3-11). Within the 17-county laborshed (region) projected for the project area, the number of prospective workers represents 0.15% of the total labor force in 1978 (see Table 3.1-4), 3.2% of those unemployed, and 6.5% of the estimated construction labor pool of 16,000 (estimated by applying state construction worker percentages to each county's labor force). The peak work force required for the project exceeds the approximately 875 unemployed construction workers in the region in 1978. However, this is the case only in the peak construction years of 1987-1988 and 1992. In all other project years the required work force could theoretically be obtained within the region. Obviously, skill requirements could reduce somewhat any direct offset of regional unemployment.

When H-Coal and other known potential regional projects are considered, the demand for construction labor is increased by a factor of 5 in the peak construction year of 1988. In other years, competing demands are greater (Table 4.1-1). Assuming a common laborshed for the H-Coal and Hancock projects, H-Coal will compete directly with the generating station project in many labor categories, and together the two projects will require 33% of the laborshed's construction labor force in 1986; this will decrease to 21% in 1987 and to 10% in 1988. Assuming some overlap of laborsheds of all of the proposed projects, together they will require from 1985 to 1987 more construction workers than are currently available in the region. Some of the projects will draw from areas to the west of the Hancock project laborshed, so that the Hancock project's labor demands probably can be met. In general, the proposed pattern of development from the Breckinridge site westward emphasizes the importance of the Louisville metropolitan area as a source for Hancock project workers (Table 4.1-4) and deemphasizes the potential importance of Owensville and Evansville because workers in those areas will be drawn to those competing projects that are more accessible.

Table 4.1-4. Source Areas of Peak Construction Work Force for the Hancock Generating Station

Area	Commuters	Inmigrants	Percent of Construction Workforce
4-county project area (Hancock, Breckinridge, Hardin and Perry)	112	175	28
Jefferson County, Kentucky (Louisville)	426		42
Daviess County, Kentucky (Owensboro)	83		8
Other Kentucky counties	95		9
Vanderburg County, Indiana (Evansville)	92		9
Other Indiana counties	28		3
Total	836	175	

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*Includes 15 transmission workers in 1988.

The projections ot source areas for Hancock project labor (Table 4.1-4) were made on the basis of present availability of labor in the region, access to the project, past response of regional labor to large construction projects, and competing projects. It is assumed that approximately the same percentage of workers would commute from each area in any year of construction, so that distribution of regional income from the project would be proportionally the same.

The peak direct income projected for the Hancock project represents an increase of 0.3% in regional (17-county laborshed) income over what would be expected without the project. Secondary employment and income resulting from the project is expected to accrue on the basis of one indirect job for each direct job. Although a multipilier of 1.8 recently has been used in the region to project indirect employment (EPA Region IV 1978), a multiplier of 1.0 is believed more reasonable because of the transitory nature of construction projects and because competing projects will induce indirect labor. Many construction workers on the Hancock project will probably come from other developments so that the net increase in new jobs will be lower than the number of jobs created (see Table 4.1-1). The direct/indirect ratio of 1 to 1 probably will be less in major urban centers and somewhat greater in rural counties. The peak combined income from both direct and indirect Hancock project employment will be $167.5 million in 1992; this will represent about 0.5% of the total regional income.

4.1.1.2.1.1 Hancock Site Alternative

Distribution of 1988 direct employment, indirect employment, and income in the four-county project area should the plant be built in Hancock county is shown in Table 4.1-5. The income increases over 1978 are included to demonstrate the relative significance of the increases in each county, assuming that total income would increase consistently in each without the project. It is evident that Hancock County would experience the most significant increases in total income under this scenario. Income increases will be comparable to relative increases in employment, as shown in Table 4.1-6. Per capita income will not be affected significantly because the average project-related income is expected to be about the same as the inflated EBI in the county (approximately $44,000).

Project EBI for the years of construction on the Hancock site is shown in Table 4.1-7. It was estimated from projected generating station construction salaries (see Table 1.3-2), transmission construction salaries (see Table 1.3-11), operating salaries during 1989 to 1995, and work force distribution. EBI without the project was estimated from Hancock County EBI in 1978 (see Table 3.1-10) and a 10% rate of increase; no population growth except that related to the project was assumed, and indirect, or induced, project income was not included. The EBI estimates probably underestimate county EBI and overestimate project EBI, but addition of indirect income, which will be about 90% of project income, would nearly double project EBI significance. Primarily the figures provide a means for examining relative impact to the project area economics.

During construction, the greatest increase in Hancock County income will be about 4.4%. Adding 90% induced income from the project could increase that to about 8%. Significant increases will not be noticed until 1986, peaks will occur in 1988 and 1992, and direct project EBI will level off at about 2.25% of the county total from 1995 through the life of the project, if no other changes in the economic structure occur.

Of all the effects projected for employment and income distribution, clearly the most significant is the potential for the project to reduce unemployment (Table 4.1-6). However, because of the skill requirements anticipated, it is not likely that all unemployed workers in the four-county project area would be employed. Also, it is more likely that many of those who are unemployed would be employed in indirect rather than direct jobs.

4.1.1.2.1.2 Breckinridge Site Alternative

With this alternative, the most project-related jobs will be created in Breckinridge County. Other commuting and location patterns are expected to remain the same because of the sites' proximity. On this basis, employment and income in the four-county project area for the Breckinridge alternative is shown in Table 4.1-8.

Induced and total income projections are 25% lower in Breckinridge county than for comparable employment in Hancock County, based on the lower median family EBI in Breckinridge (see Table 3.1-10). This difference holds throughout the calculations, although induced workers may not distribute in the

Table 4.1-5. Employment and Income in the Project Area, Hancock Site Alternative, 1988 Peak

County	Direct Employment	Direct EBI* and Percent Increase over 1978 ($000)	Indirect Employment	Indirect EBI and Percent Increase over 1978 ($000)	Total Employment	Total EBI and Percent Increase over 1978 ($000)
Hancock	96	4,358(9.7)	96	4,150(9.3)	192	8,498(19.0)
Breckinridge	52	2,355(2.8)	52	1,673(2.0)	104	4,028(4.8)
Hardin**	119	5,390(1.2)	119	3,928(0.9)	238	9,318(2.1)
Perry	85	3,850(4.0)	85	3,081(3.2)	170	6,431(7.2)
Project area total	352	15,943(2.4)	352	12,833(1.9)	704	28,776(4.3)

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*EBI = income less taxes, etc. It is estimated at 70% of gross income. Income is inflated to 1987 levels.

**Includes peak labor force for Unit 2 transmission facilities.

Table 4.1-6. Summary of Employment Effects in the Four-County Project Area, Hancock Site Alternative, 1988 Peak

County	Total Local Jobs Created	1978 Employment	% Change*	1978 Unemployment	% Change**
Hancock	192(123)	3,217	(5.9)	285	(-67.0)
Breckinridge	104(69)	6,589	(1.5)	376	(-27.0)
Hardin	238(238)	14,993	(1.6)	1,454	(-16.0)
Perry	170(101)	7,530	(2.3)	860	(-20.0)

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*Percent change if the project jobs are added to the 1978 county employment.

**Represents the decrease in local unemployment if all new jobs are filled by unemployed workers. Using 1978 figures as a benchmark may be misleading because unemployment was quite high in Hancock (8.1%) and Perry (10.3%) counties.

Table 4.1-7. Income Effects of Generating Plant Construction (in $ Million), Hancock Site Alternative

	Year													
County	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Hancock														
Workers	2	4	15	29	51	78	113[a]	144[b]	142[b]	166[b]	208[b]	175[b]	186[d]	180[d]
Project EBI	0.04	0.1	0.64	0.45	1.8	3.19	4.65	2.74	2.19	4.7	7.8	6.3	5.15	5.2
Nonproject EBI	65.2	71.7	78.8	86.7	95.4	104.9	115.4	126.9	139.7	153.6	168.9	185.8	204.4	224.8
Total EBI	65.24	71.8	79.44	87.15	97.3	108.09	120.05	129.64	142.61	158.3	176.7	192.1	209.6	230.0
Project %	0.06	0.14	0.81	0.51	1.95	2.95	3.9	2.11	2.04	2.97	4.4	3.3	2.46	2.26
Breckinridge														
Workers	1	2	9	18	31	48	51	8	8	22	48	27	3	0
Project EBI	0.03	0.06	0.27	0.61	1.17	1.99	2.3	0.4	0.6	1.3	3.08	1.9	0.22	-
Nonproject EBI	119.2	131.1	144.2	158.6	174.5	191.9	211.1	232.2	255.5	281.0	309.1	340.0	374.0	-
Total EBI	119.23	131.16	144.47	159.21	175.67	193.89	213.4	232.6	256.1	282.3	312.18	341.9	374.22	-
Project %	0.03	0.05	0.19	0.38	0.67	1.03	1.08	0.17	0.24	0.46	0.99	0.56	0.06	-
Hardin														
Workers	1	2	9	18	31	48	51	8	73	22	48	27[c]	3	0
Project EBI	0.03	0.06	0.28	0.62	1.17	1.99	2.3	0.4	2.67	1.3	3.08	1.9	0.22	-
Nonproject EBI	655.2	720.7	792.8	872.1	959.3	1055.2	1160.7	1276.8	1404.4	1544.9	1699.4	1869.3	2056.3	-
Total EBI	665.23	720.76	793.08	872.72	960.47	1057.2	1163.0	1277.2	1407.07	1546.2	1702.48	1871.2	2056.52	-
Project %	0.00	0.00	0.04	0.07	0.12	0.9	0.2	0.03	0.19	0.08	0.18	0.1	0.01	-
Perry														
Workers	2	4	15	29	51	78	83	14	12	36	78	45	6	0
Project EBI	0.04	0.10	0.64	0.45	1.9	3.19	3.76	0.64	0.61	2.12	5.0	3.17	0.45	-
Nonproject EBI	139.7	153.6	169.0	185.9	204.5	224.9	247.4	272.84	299.4	331.42	362.63	398.45	438.75	-
Total EBI	139.74	153.7	169.64	186.35	206.4	228.09	251.16	276.2	300.01	329.34	367.63	401.62	438.75	-
Project %	0.03	0.07	0.38	0.24	0.92	1.4	1.5	0.23	0.2	0.64	1.36	0.79	0.1	-

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[a] Includes Unit 1 transmission workers.

[b] Includes Unit 1 operations workers.

[c] Includes Unit 2 transmission workers.

[d] Includes all operations workers.

Table 4.1-8. Employment and Income in the Project Area, Breckinridge Site Alternative, 1988 Peak

County	Direct Employment	Direct EBI* and % Increase over 1978 ($000)	Indirect Employment	Indirect EBI and % Increase over 1978 ($000)	Total Employment	Total EBI and % Increase over 1978 ($000)
Breckinridge	96	4,348(5.3)	96	3,118(3.7)	192	7,466(8.4)
Hancock	52	2,355(5.3)	52	2,269(4.9)	104	4,624(9.4)
Hardin**	119	5,390(1.2)	119	3,964(0.9)	238	9,354(2.1)
Perry	85	3,850(4.0)	85	3,109(3.2)	170	6,969(6.8)
Total	352	15,943(2.4)	352	12,498(1.8)	704	28,441(4.1)

---

*EBI = income less taxes, etc. It is estimated at 70% of gross income. Income is inflated to 1988 levels.

**Includes peak labor force for Unit 2 transmission facilities.

four counties in the same proportion as project workers. With the assumption of distribution similar to project workers, the impact of the income changes on Breckinridge County is reduced, because of the larger total income in that county. Similar comparisons are found when employment impacts are examined (Table 4.1-9).

On the basis of percent change, new employment opportunities in Breckinridge county seem less significant than in Hancock County. However, their absolute significance would probably be greater there than in Hancock county for two reasons. First, there are relatively fewer nonagricultural and nongovernmental jobs in Breckinridge County (see Table 3.1-5), so that new jobs would be created in a sector of the economy that the county is trying to develop. Secondly, the average projected EBI for project jobs ($44,000 in 1988) is 26% higher than the average projected EBI in the county without the project ($32,450). Thus, these opportunities will produce greater economic benefit in Breckinridge than in Hancock County, where projected average EBI without the project is about the same as with the project.

The pattern of income changes in Breckinridge County, with the project located there, generally reflects that in Hancock County except that the relative significance of direct project income is less because of the larger base income (Table 4.1-10). The peak project income accounts for 2.5% of the county total compared with 4.4% in Hancock County with the Hancock alternative. Project families will account for about 2% of county total, producing a slight increase in median income.

Table 4.1-9. Summary of Employment Effects in the Four-County Project Area, Breckinridge Site Alternative, 1988 Peak

County	Total Jobs Created (Local)	1978 Employment	% Change*	1978 Unemployment	% Change**
Breckinridge	192(123)	6,589	(2.8)	376	(-51.0)
Hancock	104(69)	3,217	(3.1)	285	(-37.0)
Hardin	238(238)	14,993	(1.6)	1,454	(-16.0)
Perry	170(101)	7,530	(2.2)	860	(-20.0)

[*] Percent change if the project jobs are added to the 1978 county employment.

[**] Represents the decrease in local unemployment if all new jobs are filled by unemployed workers. Using 1978 figures as a benchmark may be misleading because unemployment was quite high in Hancock (8.1%) and Perry (10.3%) counties.

4.1.1.2.1.3 Employment and Income Effects of Plant Operations, Both Alternatives

When completed, the generating facility will employ 180 people. The effects of the direct income in the project counties (assuming the worst case/best case scenario that all workers will live in the county in which they are employed) can be seen in the 1995 columns on Tables 4.1-7 and 4.1-10. As with construction, operation of the Hancock plant will increase total EBI by a greater percent in Hancock County because of the smaller county income. However, impact on projected average EBI will be greater with the Breckinridge alternative, as will the incremental increase in industrial jobs. On the other hand, when the H-Coal operations work force (1500 workers) is considered, the effects of 180 generating station jobs become negligible. The effects of the H-Coal operating work force probably will diminish effects of the Hancock operating work force under the Hancock site alternative as well, because Hancock Conty will attract many H-Coal workers.

The assumption that all Hancock operating personnel will live exclusively in the county of work is obviously unrealistic given the proximity of the sites and current commuting patterns. The effect of spreading these 180 workers and their dependents over more than one county would be to reduce the magnitude of adverse impacts on any one county; the beneficial effects of increased income would be similarly reduced. Should distribution of the operating work force be widespread among three counties, both types of impacts would be small at the county level.

Table 4.1-10. Income Effects of Generating Plant Construction (in $ Million), Breckinridge Alternative

County	Year 1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Hancock														
Workers	1	2	9	18	31	48	51	8	8	22	48	27	3	0
Project EBI	0.03	0.06	0.27	0.61	1.12	1.99	2.3	0.4	0.6	1.3	3.08	1.9	0.22	-
Nonproject EBI	65.2	71.7	78.8	86.7	95.4	104.9	115.4	126.9	139.7	154.9	168.9	185.79	204.37	-
Total EBI	65.23	71.76	79.07	87.31	96.57	106.89	117.7	127.3	140.3	156.2	171.9	186.69	204.59	-
Project %	0.05	0.08	0.34	0.7	1.21	1.86	1.95	0.31	0.4	0.8	1.79	1.01	0.1	-
Breckinridge														
Workers	2	4	15	29	51	78	113[a]	144[b]	142[b]	166[b]	208[b]	175[b]	186[d]	180[d]
Project EBI	0.04	0.1	0.64	0.45	1.9	3.19	4.65	2.74	6.12	4.7	7.8	6.3	5.15	5.2
Nonproject EBI	119.2	131.1	144.2	158.6	174.5	191.9	211.1	232.2	255.5	281.0	309.1	340.01	374.01	411.41
Total EBI	119.24	131.2	144.84	159.05	176.4	195.09	215.75	234.94	258.41	285.7	316.9	346.31	379.16	416.61
Project %	0.03	0.08	0.56	0.28	1.08	1.64	2.15	1.17	1.13	1.65	2.46	1.82	1.36	1.25
Hardin														
Workers	1	2	9	18	31	48	5	8	73[c]	22	48	27	3	0
Project EBI	0.03	0.06	0.28	0.62	1.17	1.99	2.3	0.4	2.67	1.3	3.08	1.9	0.22	-
Nonproject EBI	655.2	720.7	792.8	872.1	959.3	1055.2	1160.7	1276.8	1404.4	1544.9	1700.8	1870.9	2058.0	-
Total EBI	665.23	720.76	793.08	872.72	960.47	1057.19	1163.0	1227.2	1407.07	1546.2	1703.88	1872.8	2058.22	-
Project %	0.00	0.00	0.04	0.07	0.12	0.19	0.2	0.03	0.19	0.08	0.18	0.1	0.01	-
Perry														
Workers	2	4	15	29	51	78	83	14	12	36	78	45	6	0
Project EBI	0.04	0.10	0.64	0.45	1.9	3.19	3.76	0.64	0.61	2.12	5.0	3.17	0.45	-
Nonproject EBI	139.7	153.6	169.0	185.9	204.5	224.9	247.4	272.2	299.4	329.3	362.23	398.45	438.3	-
Total EBI	139.74	153.7	169.64	186.35	206.4	228.09	251.16	272.84	300.01	331.42	367.23	401.62	438.75	-
Project %	0.03	0.07	0.36	0.24	0.92	1.4	1.5	0.23	0.2	0.64	1.36	0.79	0.1	-

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[a] Includes Unit 1 transmission workers.

[b] Includes Unit 1 operations workers.

[c] Includes Unit 2 transmission workers.

[d] Includes Unit 2 operations workers.

4.1.1.2.2 Effects on Business, Industry, and Agriculture

Because most structural materials for the project will be purchased outside the region, and because the project is not expected to induce satellite industry, benefits to regional industry will not be widespread. Effects on agricultural activity also will be localized and dependent on plant site. Unlike industry and agriculture, however, businesses in both the region and project area will benefit to a certain extent, based on work force distribution and availability of support functions.

Impacts to businesses associated with the project will be from direct expenditures by KU for materials and services, direct expenditures for goods and services by immigrants, direct expenditures by commuting workers, and indirect business activity generated by the direct activity.

Total potential expenditures in the 17-county laborshed could be as much as $233.33 million during construction, exclusive of any expenditures for heavy equipment and construction materials. The secondary effects of these expenditures can be assumed to be an equal number of induced dollars.

Sources of potential project-related business revenues in the four-county project area, based on its share of the regional construction work force (28%; Table 4.1-4), are shown in Table 4.1-11. The effect of this level of potential business on the four counties can be illustrated by comparing it to the level of retail sales projected for the area based on 1978 levels, after assuming that 40% of the local construction work force's EBI will be spent on housing and utilities (Table 4.1-12). Of the estimated direct local increase in retail business activity that will result from the construction of the Hancock plant, $117.62 million may be spent in the project area (plus $2.3 million for transmission construction materials). The amount estimated to be spent in 1992 represents approximately 2.1% of the projected retail sales in the four-county area in 1992. The relative proportion will be less in other construction years; during operation the impact will be negligible (about 0.24% per year). Assuming that indirect income generated in the project area would amount to about 90% of direct income (because of the relatively high construction salaries; see Tables 4.1-5 and 4.1-6) the impact of project-related economic activity would increase to about 4% during 1992; at the rate of 100% during operation, project-related impact will amount to about 0.5% per year of operation.

The Hancock project alone probably will not substantially alter shopping patterns in the general area. Tell City, Hardinsburg, Hawesville and Lewisport will provide most goods and services needed on a daily or weekly basis. Larger less frequent purchases will be made in Elizabethtown and Owensboro (which will direct some proportion of potential sales from the four-county area) and even Louisville and Evansville. However, with establishment of the H-Coal project, substantial changes in local availability of goods and services will probably occur because at least 2,000 to 3,000 people, if not more, may move into the area, and overall economic activity will be significantly increased. This should lead to additional business establishment at least in Cloverport and Hawesville beyond that expected with only the Hancock project. This, in turn, will lead to a greater concentration of retail business in the project vicinity and reduce dependence on more distant places such as Elizabethtown and Owensboro.

Table 4.1-11. Potential Effects of Hancock Generating Station on Business in the Four-County Project Area

Source	Peak Construction Year ($000)	Construction Total ($000)	Operation per Year ($000)
Locally purchased equipment, goods, and services[a]	5,589	28,599	None Stated
Construction work force, four-county project area[b]	16,435	73,803	
Construction work force, other parts of region[c]	3,018	13,556	
Operational work force	3,360	19,495	4,172[d]
Total	28,402	135,453	

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[a] Assuming 50% of KU's projected $57 million local purchase estimate (see Table 1.3-3) can be supplied in the four counties.

[b] 28% of total construction work force salaries in 1988 (see Table 1.3-2) minus 30% for taxes, etc.

[c] Assuming construction work force from other counties in the laborshed (region) will spend 5% of income in the four-county project area.

[d] 1989 constant dollars

Table 4.1-12. Effects of the Hancock Generating Station on Retail Sales of Goods and Services in the Four-County Project Area

County	Total 1992 Retail Sales* ($000)	Direct Potential Added Peak Construction** ($000)	Direct Potential Added Total Construction** ($000)	Direct Potential Operation per Year*** ($000)
Breckinridge	91,152	1,897	10,666	219
Hancock	22,659	472	2,660	54
Hardin	596,139	12,406	69,684	1,431
Perry	129,304	2,691	15,124	312
Total	839,254	17,466	98,134	2,016

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*See Table 3.1-7. 1978 figures are inflated to 1992 levels.

**Calculated by estimating 28% of total construction work force salaries, determining EBI, subtracting 40% for housing and utilities expenditures, and allocating according to 1978 sales. Includes local purchases of equipment, goods and services.

***1992 constant dollars.

4.1.1.2.2.1 Hancock Site Alternative

Industry. The power plant is not expected to induce development of other industry, nor is it expected to preclude development of other high-SO_2 emitting facilities, although it would contribute to ambient emissions concentrations. Hancock County presently is more industrial than Breckinridge County, so that additional industry would not enlarge the industrial base to the same extent as in Breckinridge. Hancock County wants to expand its industrial base but desires several nonemitters or low-SO_2 facilities or high-SO_2 facilities with a larger permanent work force.

Agriculture. Development of the Hancock site will eliminate approximately 4% of the county's current corn, soybean, and tobacco production (Table 4.1-13). The percentage of timber production that will be eliminated is unknown, as discussed in Section 4.1.2. The approximate 4% reduction in crop sales is a minor portion of Hancock County agricultural sales, which were estimated to be 6.4% of its economic activity in 1972 (see Table 3.1-9). The reduction in crop sales would have little impact on total county economic activity, providing retail sales activities increase as projected.

Table 4.1-13. Major Crop Production, 1979 Estimates, Hancock and Breckinridge Sites and Counties

	Hancock			Breckinridge		
Major Crops	County	Site	%	County	Site	%
Corn:						
Acres planted	5,000	156	3.1	41,000	168	0.4
Production (bu)	423,000	15,600	3.7	3,493,600	16,800	0.5
Crop value ($)	1,015,200	37,440	3.7	7,860,600	37,800	0.5
Soybeans:						
Acre planted	17,000	432	2.5	23,500	605	2.6
Production (bu)	467,600	18,360	3.9	697,500	22,688	3.3
Crop value ($)	3,436,860	134,946	3.9	4,882,500	158,816	3.3
Tobacco:						
Acres planted	800	18	2.3	2,500	9	0.4
Production (bu)	1,360,000	54,000	4.0	4,250,000	27,000	0.6
Crop value ($)	1,740,800	69,120	4.0	5,440,000	34,560	0.6

Crop value and production estimates for the sites are based on personal communication with onsite landowners and Soil Conservation Service agents (1979) (see Table 3.1-9).

Acreage and production estimates for the counties are based on 1979 estimates from the Kentucky Crop and Livestock Reporting Service.

4.1.1.2.2.2 Breckinridge Site Alternative

Industry. As in Hancock County, development of the generating station on the Breckinridge site is not expected to induce industrial employment opportunities in the county, nor is it expected to preclude them. It will expand the county's industrial base. The construction employment opportunities will exceed existing industrial employment fivefold, and operational employment will nearly double existing industrial jobs (see Table 3.1-6).

Agriculture. About 1% of the county's corn and tobacco production and about 3% of its soybean production will be eliminated by site development. Again, timber production is unknown for this site, but it may be equal to or only somewhat more than on the Hancock site despite greater extent of woodlands. Because of past timber harvest, woodlands on the Breckinridge site are not as mature as those on the Hancock site and present merchantable timber appears to be only somewhat greater, if any, than that on the Hancock site.

4.1.1.2.3 Effects on Housing

The estimated demand for housing associated with the proposed project and alternatives is shown on Table 4.1-14. There may be some housing demand from dislocated project site residents, but they presumably would relocate several months prior to construction and may be provided with substitute housing as a part of the compensation process. A maximum demand for 86 purchase units (during operation) and 41 rental units (during construction) is anticipated with the project in either of the counties. Using the 1970 census figures as a benchmark (because 1980 housing figures are unavailable), the following significance can be attached to these increases in housing requirements.

Table 4.1-14. Potential Housing Demand by Workers Relocating to the Project Area during Construction and Operation

	Hancock Site Alternative						Breckinridge Site Alternative			
	Hancock County		Breckinridge County		Perry County		Breckinridge County		Hancock County	
Type of Unit	Purchase	Rental	Purchase	Rental	Purchase	Rental	Purchase	Rental	Purchase	Rental
Peak Construction Demand[a]	29	41	12	17	29	41	29	41	12	17
Operation Demand[b]	86	22	0	0	0	0	86	22	0	0
(Net)[c]	(57)	(0)					(57)	(0)		

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[a] Numbers are immigrant construction workers. The assumption is that 40% will require purchase housing and 60% will require rental housing.

[b] The assumption is that 80% of the immigrant operation work force will require purchase housing.

[c] The assumption is that construction worker housing will become available so that there will only be a net increase in demand of 57 purchase units.

4.1.1.2.3.1 Hancock Site Alternative

With this alternative, maximum housing demand, compared with housing availability, is expected to be:

	Hancock	Breckinridge	Perry
Purchase demand	86	12	29
1970 owner occupied (see Table 3.1-22)	1606	3514	4655
Percent owner occupied needed to meet demand	5.3	0.3	0.6
Rental demand	41	17	41
1970 renter occupied (see Table 3.1-22)	505	1103	1099
Percent renter occupied needed to meet demand	8.1	1.5	3.7

If it is assumed that usable housing is occupied at about 95% of the total available, then there would be adequate available purchase housing and a shortfall of 16 units of rental housing in Hancock County. However, this assumes that total housing has remained unchanged from 1970 levels. Because the net housing stock available has increased, it is likely that sufficient units are available, although they may not be of the size and quality that would be demanded by well paid workers. Thus, some new construction would be expected in order to provide the necessary quality of housing, although not necessarily the quantity.

4.1.1.2.3.2 Breckinridge Site Alternative

Maximum housing demand compared with housing availability under this scenario is expected to be:

	Breckinridge	Hancock	Perry
Purchase demand	86	12	29
1970 owner occupied	3514	1606	4655
Percent owner occupied needed to meet demand	2.4	0.7	0.6
Rental demand	41	17	41
1970 renter occupied needed to meet demand	1103	505	1099
Percent renter occupied needed to meet demand	3.7	3.4	3.7

All potential demand could theoretically be met with available unoccupied housing except possibly for a few rental units in Hancock County. However, the potential problem of quality-of-housing available would also occur in Breckinridge, and this would be compounded by the distribution of housing in the county. The majority of available housing is probably around Hardinsburg, and because it would be more convenient for workers to live closer to the plant, it is probable that some new housing construction would occur in the Cloverport area.

4.1.1.2.3.3 Additional Housing Demand, Both Alternatives

Because of the marginal location of the proposed sites relative to major worker source areas, it is expected that some demand for transient housing (e.g., motel) or temporary rental housing (e.g., rooming on a weekly basis) may occur. Some workers may have their own campers or trailers. Demand may vary seasonally, with more temporary housing desired in winter than in summer. Probably the greatest potential demand will be from 426 workers projected to commute from the Louisville area. Because this is a long commute even in good weather, at least some of these workers will require temporary housing. The 100 or so hotel and motel rooms available in the three counties surrounding the sites probably will be inadequate to meet demand.

Likely alternatives are primarily available in Owensboro and Elizabethtown. However, since the latter is so close to Louisville and presents similar commuting problems, it probably will not be considered often. Other choices include a few small motels along I-64 in southern Indiana. Although it is not possible to project accurately how much temporary housing demand may be generated, available hotel and motel spaces in the project area would accommodate only 20% of the Louisville commuters at best, and this would preclude other accommodations. Additional rental housing (apartments or homes) might be available, but would be limited after inmigrant workers are accommodated. Thus, there is a potential for considerable impact to the available transitory housing market in the area if other sources are not provided. The Applicant has not proposed to provide worker housing (e.g., mobile home dormitories) on the site.

4.1.1.2.3.4 Cumulative Demand for Housing, Both Alternatives

The other projects proposed for the region will vastly compound projected housing shortages. The Hancock project will be affected in at least three ways. First, the direct competition for housing that will result from the H-Coal project will greatly increase demand for local housing and force prices up. Second, because of regional competition for labor, inmigration will probably be greater than that projected solely for the Hancock project; this will increase project-related housing demand. Third, the number of other projects to the west of Hancock and Breckinridge counties will reduce the potential safety valve role that Owensboro might play to offset shortfall in project area demand. This may have the effect of increasing housing demand in towns to east, such Elizabethtown. Thus, problems with housing are limited when only the Hancock project is considered, but other regional developments could make the housing problem critical.

4.1.1.2.4 Effects on Transportation

Impacts to transportation in the project area will be of several types. Road traffic near the sites would be significantly increased during peak construction. During transmission system construction, some disruption of travel may occur when conductors are strung across roads. Train and barge traffic will increase during construction, although neither is expectd to produce significant impact. Seven to eight additional barges will travel through the locks at Cannelton Dam each day during operation of the plant and some increase in truck traffic to the generating station will occur during operation. Barge traffic increase will be about 4.5% over present levels and should not demand additional locks or cause significant congestion.

4.1.1.2.4.1 Hancock Site Alternative

If the national ratio of 1.9 construction workers per vehicle is maintained during the Hancock project, automobile traffic on U.S. Highway 60 near the site and on Kentucky 1406 to the site would increase by 11 cars per day at the beginning of construction to 550 cars per day at peak construction in 1992. This rate of car travel would increase the 1979 rate of use of U.S. 60 near Hawesville by 50% and increase traffic on Kentucky 1406 by 100% (assuming 470 cars per day associated with the Willamette Industries workers). During operation, automobile usage of 1406 would be increased by about 60% over the present.

The increases during peak construction would cause congestion on U.S. 60 and its intersection with Route 1406. Rush hour traffic would be most serious at the intersection and on U.S. 60 between the intersection and Hawesville, where U.S. 60 is hilly and winding and has heavy truck traffic. East of the intersection, congestion would be less. Other major bottlenecks will be in Hawesville at the toll bridge to Indiana and in Cannelton. East of the site, there might be congestion in Cloverport, although absence of cross-river traffic facilitates travel through this area.

Without additional roads or lanes some congestion will be unavoidable. However, if Route 1406 and Skillman Road, which is a continuation of 1406 and also accesses the site from U.S. 60 (see Figure 3.1-9), are maintained and if the Commonwealth installs traffic lights at both junctions with U.S. 60, traffic will be dispersed and intersections that are potentially dangerous will be safer. Skillman Road is narrow, subject to washout, and would hinder traffic unless upgraded. Staggering of the workday between KU and Willamette Industries also would reduce peak congestion. In Hawesville, the most reasonable mitigation of potential congestion would be to make additional police available to control traffic at rush hours during peak construction. Other towns (e.g., Cloverport and Cannelton) might require similar assistance, although not to the extent needed in Hawesville. All roads in the immediate project area will require resurfacing to offset increased wear during constuction.

4.1.1.2.4.2 Breckinridge Site Alternative

Traffic at Holt Bottom along Route 144 will be increased two to threefold during peak construction, and will be about double existing levels during operation. The rate of travel on U.S. 60 will increase as with the Hancock alternative, but the increase may not be so great if some Louisville area commuters come in on Route 144 from the northeast. Nevertheless, the intersection of 144 and U.S. 60, which is potentially dangerous, will require traffic control. Congestion will be substantial in Cloverport as well as in the Hawesville area. Eastward congestion will probably be slight because U.S. 60 is relatively straight and there are few towns between Cloverport and Hardinsburg. In general, traffic will be less of a problem if the Beckinridge site is developed.

4.1.1.2.4.3 Traffic Impacts of Hancock and H-Coal Projects

If the H-Coal project develops, traffic in the vicinity of both sites will be greatly increased. For example, in 1987, just before the first construction peak for the Hancock project, H-Coal traffic could amount to 1250 cars per day, or more than twice the peak Hancock project traffic. Added to that number would be nearly 500 Hancock project vehicles. This level of traffic would at least double U.S. 60 use, result in major congestion in Cloverport and Hawesville, and if the Breckinridge alternative is developed, increase traffic on KY 144 seven to eight times. By 1992, the H-Coal operation work force would drive 790 cars on U.S. 60 and KY 144 each day in addition to the 550 vehicles operated by KU project workers. Traffic generated by development farther west probably would not noticeably add to congestion in the Hancock project area.

4.1.1.3. General Social and Community Effects

During the construction phase of the Hancock project, people who relocate to communities in the project area will do so for a period of a year or so up to six or seven years. Their interest in and willingness to assimilate into the community structure and life will be influenced by how they perceive their move (transitory or semi-permanent) and how they perceive the social order and institutions of the community.

Operational workers probably will be more consistent in their veiws towards moving to the area. They will become permanent residents and will probably adapt more openly and readily.

4.1.1.3.1 Hancock Site Alternative

Probably the most significant social impacts of this alternative already have occurred. Resistance to the project has been a fact of Hancock County life since 1978 and roles, reputations, and attitudes have been formulated around it. People associated with Kentucky Utilities or regulatory agencies perceived to be in favor of the project are generally unwelcome in the county and, unless attitudes change significantly prior to construction, antagonism may occur. Antagonism may develop toward local persons who favor the project but have generally remained silent, as well as toward project workers. However, the absence of bars and similar gathering places in the county will reduce the potential for worker/resident contact and conflict.

The acceptance of immigrant workers may be hindered by perceived or real resistance on the part of neighbors, business people, school children, etc., and until the project is generally accepted or tolerated, newcomers could feel alienated. This impact will depend on the magnitude of resistance, but even a small level of resistance would make integration difficult.

Impacts to institutions within the community will depend largely upon internal discord over the project rather than on new members or participants. The overall effect may be a perpetuation of changes that have occured since the project was announced.

During operation of the facility, most of the resistance probably will have dissipated. The communities in which new residents would live (e.g., Hawesville, Lewisport) would experience some changes in social order. Most new residents would be in the upper income brackets in the county and would be expected to participate in social and community-oriented organizations. Families of newcomers will integrate into other community organizations such as churches and school activities. Overall, however, the effect of these changes will be to intensify and continue the existing social order. The net effect of the influx of new people will probably be beneficial to the communities and their institutions.

4.1.1.3.2 Breckinridge Site Alternative

Although some of the landowners of the Breckinridge site do not want their land taken and some residents oppose industrial development, the project is generally perceived as desirable in Breckinridge County. Organized opposition probably will be limited and many of the social impacts likely to occur in Hancock county will not occur in Breckinridge. As a result, inmigrants living in the county during construction will feel freer to participate in community organizations and institutions than they would in Hancock County, and they will probably assimilate sooner. However, again, the level of assimilation will be influenced by the workers' desires to participate in the communities.

Impacts of operational workers on the communities will be similar to those projected for Hancock County, but they may be even more pronounced if many people reside in Cloverport. This part of Breckinridge County is in a state of general economic stagnation or decline, and the infusion of even a small number of new, relatively affluent people will be significant. However, this same stagnation may deter people from choosing to live in the vicinity of the project and encourage them to locate farther away and, perhaps, out of the county. Under the assumption that people will live near their work, settlement in the northwestern part of the county will lead to substantial beneficial impacts to the communities in the area.

The KU proposed project has generally been overshadowed in Breckinridge County by the H-Coal proposal. Because H-Coal is so much bigger (five times the peak construction work force and eight times the operational work force), favorability and opposition to development in the county focuses on that project rather than on the generating station. Opposition to H-Coal apparently has not extended beyond Breckinridge County to date, even though it will probably impact the project area communities more so than the Hancock project.

4.1.1.4 General Effects on Municipal and Government Services

The political structure of communities in the project area will not be affected but finances, police protection, and similar facets of the communities will be.

4.1.1.4.1 Local Government Finance

Tax revenues at local and state levels will increase through:

- Local property taxes levied on industrial land values and additional personal real estate and other property values due to immigration of workers.
- State taxes levied on real estate and tangible industrial property as well as on personal real estate and property.
- Sales tax receipts from purchase of goods and services.
- Personal income tax receipts.

Income taxes are difficult to generalize because of graduated rates and variable deductions. Using an average Federal tax payment of 25% yields a total revenue from construction of $95.3 million. Payment will range from $174 thousand in 1982 to $21 million in 1992. Operation workers will pay about $35 million (in 1989 dollars) in Federal taxes over the life of the project.

Kentucky tax rates are estimated to average 5%, which will result in $16.3 million in state revenues during construction, ranging from $30 thousand in 1982 to $3.6 million in 1992. Operation personnel will pay approximately $6 million (in 1989 dollars) over the life of the project. The estimated 14% of the work force who will be Indiana residents (Table 4.1-4) will pay 2% state tax, or about $1.1 million during construction. Sales tax receipts will increase in the project area by up to 4 or 5%.

One aspect of tax impacts that is frequently associated with major developments of this type is the timing of benefits. Several major public costs may occur with the project (e.g., need for highway improvements or additional police) before the project generates sufficient revenue to offset them. Thus, although the net effect of project development will be to significantly increase tax revenue, there may be a lag of several years between need for and receipt of additional revenues. However, both Hancock and Breckinridge counties currently operate with excess revenues, suggesting a financial cushion that could be applied to meeting these needs.

4.1.1.4.1.1 Hancock Site Alternative

Personal Taxes. Hancock County's occupational tax (see Subsection 3.1.2.7.2) will be the single most significant tax benefit to the county. Assuming that about 82% of the work force would be nonresidents, an estimated $3.1 million would accrue in occupational taxes during construction of the plant. These tax payments will range from $5.7 thousand in 1982 to $687 thousand in 1992. The peak figure represents a 41% increase over total 1979 Hancock County tax revenues ($1.666 million). However, continued increases in county revenues (the occupational tax alone is expected to top $1 million in 1981) will reduce this percentage substantially by 1992.

Workers will also contribute to the property tax revenues at the county and state level. As discussed previously, as many as 80 workers may purchase housing in Hancock Conty, 18 in Breckinridge County, and 36 in Perry

County (Table 4.1-14). Taxes on these properties will vary and change over the next 35 years, and their impact is uncertain.

Facilities Taxes. Using current (1980) tax rates and current value estimates for the Hancock project, Kentucky Utilities estimates that these taxes will be paid:

	Value for State Taxes[1] ($000)	Tax[2] ($000)	Value for Local Taxes[1] ($000)	Tax[2] ($000)
Unit 1 (1988 $)	737,000	1,483	178,746	640
Unit 2 (1992 $)	600,000	940	46,621	167
Both Units (1992 $)[3]	1,640,335	3,033	298,936	1,069

[1] Based on estimates provided by the Applicant. Transmission system values are included.

[2] Based on rates in effect 12-3-80.

[3] No depreciation of Unit 1 is included.

In 1988, Unit 1 facilities would nearly double the county assessed value for state taxes, and would account for a 60% increase in evaluation for local tax purposes. If current tax rates were maintained, local tax payments by KU would be an increase of nearly 280% over 1979 payments (after accounting for inflation). The effect of the completed facility would be to increase the county's state tax base by about 150%, the local tax base by 75%, and the local property tax revenues by 330% over 1979; total county revenues would be increased by 21% over present level. However, these increased tax receipts will not be available to the county until after peak construction, creating a lag between need for and availability of added revenues.

4.1.1.4.1.2 Breckinridge Alternative

If the project is located in Breckinridge County the increase in assessed value for state taxes will be higher (200%) but that for local taxes would be less (47%). Total county tax revenues will be increased by 54% over current levels (after adjustment for inflation); property taxes would rise by nearly 200%. The relative increase in local property taxes resulting from this project would be more significant in Breckinridge than in Hancock county because Breckinridge relies more heavily on property taxes for total revenue; other tax impacts that would occur at the state and Federal levels would be comparable.

The relative impact of the generating station and H-Coal cannot be assessed at present because H-Coal tax values are unknown.

4.1.1.4.2 Social Services

It is not anticipated that social services will be adversely impacted as a result of the proposed project because the net effect will be to improve the overall economy in the project area. The need for social services will be reduced because unemployment will be reduced as a result of increased project and induced job opportunities. Another beneficial effect will be the increased tax revenues resulting from the project. Although these funds would go to the Commonwealth for allocation on an "as required" basis, the potential for improved social services in the project area would be created.

Whereas the Hancock project alone would probably have a beneficial effect on social services by reducing demand, the cumulative effect of H-Coal and Hancock projects will have adverse impacts, particularly on people unable to work and those on fixed or limited incomes. Two sources of adverse impact can be projected: economic problems that will result from intensified competition for housing and rising prices for goods and services, and stress that will result from crowding, congestion, and changes in community composition. Impact will occur in both counties but will be somewhat more severe in Breckinridge County where the population is slightly older, incomes are relatively low, and lifestyles are established. The changes that will occur as a result of maximum cumulative construction work force (5000) and their dependents and some proportion of 1700 operational workers plus their dependents will be substantial and will lead to the need for additional housing assistance, food stamps, medicare, and general welfare support for those people who are unable to benefit from the projects.

4.1.1.4.3 Health Care

The potential for accidents will be increased during construction of the proposed facility and, to a lesser extent, during operation. Strain on emergency medical services will be reduced by onsite first aid facilities. Presence of an ambulance would further reduce impact on local emergency services.

Increased traffic on area highways will have a twofold effect: More traffic accidents will occur and road access to hospitals will be slowed during congested periods. This problem is compounded because of the lack of hospitals and medical personnel in the vicinity of the sites and the need to take people requiring care to Hardinsburg, Tell City, or Owensboro.

The cumulative effects on health care of the H-Coal and other projects in the region will be variable. Additional population, development, and traffic will increase the demand for medical services, especially west of the Hancock and Breckinridge sites, and the additional H-Coal traffic congestion will impact access from the project area to health care centers. On the other hand, the increased population that the H-Coal project will induce in Cloverport and Hawesville may be sufficient to attract doctors to the area. Increased tax revenues in these counties may support construction of public health care facilities, or at least greater demand may support private clinics, if not a hospital.

4.1.1.4.4 Municipal Services

The number of police in the project area counties is considerably lower than the 1.4 to 3 police per 1000 population that are generally considered adequate in rural areas (see Table 3.1-16) (Bureau of Reclamation 1977). A peak work force of up to 1000 people (most only daily) may seriously stress services. Potential traffic congestion and resulting accidents could seriously impact both the county sheriffs and the community police in Hawesville and/or Cloverport. It is probable that several additional full time or part-time officers will be needed in the area (with more in the project county) during construction.

It is not anticipated that the risk of fire and the need for fire fighting services will be affected by the increased housing units that inmigrant workers will build because percentage increase of such units is so small as not to pose a threat. During land clearing, there will be a potential for fires at the generating station site and along the transmission corridor, although fire-control equipment is expected to be adequate.

Municipal sewer and water supplies will not be adversely impacted by the proposed project. Sewage and water facilities will be built on the project site to accommodate all construction and operation requirements. The Applicant states that all construction waste will be disposed of in compliance with all local, state and Federal guidelines. Although landfill facilities currently are limited in the project area, it is assumed that the project county will comply with recent Commonwealth legislation requiring county identification of landfill sites. If so, the project will have no impact on solid waste disposal facilities during construction.

Additional housing construction associated with the project probably will not exceed 70 or 80 units in either Hancock or Breckinridge Counties. The relatively new secondary sewage treatment systems in Hawesville and Cloverport could accommodate all of the added demand, especially if some people choose to live in rural areas. Likewise, no adverse impacts to water supplies are likely. Addition of H-Coal project demands, however, would substantially increase demand and possibly result in a shortfall in water availability in Hawesville and Cloverport.

4.1.1.4.5 Education

School systems in the project area will experience some increase in enrollment during construction and operation of the proposed project. There also will be fluctuating enrollments during construction, as families move into and out of the project area. Both Hancock and Perry counties have had experience with major construction projects in recent years, so that administrators are familiar with the kinds of problems that can occur. Perry County schools will be only slightly affected by anticipated increases.

4.1.1.4.5.1 Hancock Site Alternative

Changes in school enrollment that may occur should the generating station be in Hancock County are shown on Table 4.1-15.

At peak construction, school enrollment will increase by about 4% over that of the late 1970s. This same increase will prevail throughout the life of the project. The associated budget increases theoretically would be met through increased tax revenues, although during construction some timing differences may develop between revenue availability and need. However administrators contacted in Hancock County felt that additional students would be accommodated within the system without undue stress.

The projected impact to student-teacher ratios probably are no more than occur from year to year in individual grades, and the projected average ratio of 25/1 is consistent with ratios throughout the U.S. Overall, it is likely that fluctuations in enrollment and the potential disruption associated with new students coming in at odd times will result in more problems than will changes in the average numbers.

Table 4.1-15. Changes in School Enrollment, Hancock Site Alternative

	Peak Construction					Operation			
				Student/Teacher Ratio				Student/Teacher Ratio	
County	Current Students[c]	Expected Increase[a]	% Change	1977-1978[d]	Peak Period	Expected Increase	% Change	1977-1978[d]	Operation
Hancock[b]	1727	69	3.8	23/1	24/1	108[d]	6.2	23/1	25/1
Breckinridge	3207	34	1.0	18/1	18/1	–	–	–	–
Perry	4300	69	1.6	17/1	17/1	–	–	–	–

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[a] Assumes 1.0 school age dependent per immigrant worker.

[b] Includes Immaculate Conception School in Hawesville.

[c] See Table 3.1-27.

[d] Average of more than one school system.

4.1.1.4.5.2 Breckinridge Site Alternative

The potential effects of construction and operation on school systems in this scenario are shown on Table 4.1-16. The relative impact will be less than under the Hancock alternative. Because of the existing population distribution in the county and that expected, it is possible that those impacts occurring may concentrate on Cloverport schools so that relative impacts would be greater than those proposed for the county.

Student turnover during construction also may be concentrated in the Cloverport area. These considerations, combined with the fact that Breckinridge schools have not had the experience with major construction projects, suggest that the potential for temporary adverse impacts is real. However, because county schools have a low student-teacher ratio and enrollments have been declining, the capacity exists for absorbing additional students.

4.1.1.4.5.3 Cumulative Effects of the Hancock and H-Coal Projects

Models of H-Coal project population distribution have not been developed but even conservative estimates would indicate that several hundred to 1000 additional students might be expected in area schools during construction, and perhaps 1000 during operation. The contribution of Hancock project children to this scenario would be minimal. The overall effect would be the need for significantly increased school capacity, including as many as 40 teachers and additional classroom space in Cloverport and Hawesville, especially. Education needs during construction would be difficult to meet because they would fluctuate significantly, and increased revenues would not be available. During operation, the effects of increased demand would be steady and manageable, especially with increased revenues.

Table 4.1-16. Changes in School Enrollment, Breckinridge Site Alternative

		Peak Construction				Operation			
				Student/Teacher Ratio				Student/Teacher Ratio	
County	Current Students[c]	Expected Increase[a]	% Change	1977-1978[d]	Construction	Expected Increase	% Change	1977-1978[d]	Operation
Breckinridge	3207	69	2.1	18/1[d]	18/1	108	3.3	18/1	20/1
Hancock[b]	1727	34	1.9	23/1	24/1	–	–	–	–
Perry	4300	69	1.6	17/1	17/1	–	–	–	–

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[a] Assumes 1.0 school age dependent per immigrant worker.

[b] Includes Immaculate Conception School in Hawesville.

[c] See Table 3.1-27.

[d] Average of more than one school system.

4.1.1.5 Summary of Effects on Population and Socioeconomic Conditions

By itself the Hancock project on either site will create relatively few adverse effects on population and socioeconomics. Those that will occur (e.g., traffic congestion or a shortfall of tax revenue during construction) can be planned for and mitigated. However, these problems are relatively minor when the Hancock project is contrasted with the H-Coal project, which is several times larger. Although proposed for Breckinridge County, people and impacts associated with the project will overflow into Hancock County and create demands on housing, services, highways etc. that will overshadow those anticipated for the Hancock project. Because of the size and imminence of the H-Coal project, coping with its demands may seriously stress community resources. By the time measures to deal with H-Coal impacts are in place, the much smaller demands of the Hancock project probably will be met easily. This will have the overall effect of minimizing any incremental impacts attributable to the Hancock project to the extent that they may not even be noticeable.

4.1.2 Land Use

Construction and operation of the Hancock Generating Station will have a major impact on onsite agricultural, woodland, and recreational land use. On the project area and regional scale, transportation, recreation, housing, commerce, and industry will be appreciably affectd, while water resources, zoning, and mineral resources will experience slight effects.

4.1.2.1 General Effects on Land Use

The effects of the Hancock project on several land uses (transportation and linear, residential, commercial, and industrial uses) were discussed above relative to population growth and socioeconomic changes. These effects are summarized in Table 4.1-17, as are those effects associated with other land uses in the project area that are discussed in detail in this section. Summaries of specific differences in kind and magnitude of effects on onsite land use between the Breckinridge and Hancock site alternatives also are given in the table. Onsite impacts differ primarily on the basis of potential loss or disturbance of natural resources specific to each site (e.g., Town Creek Embayment, Jeffry Cliff).

Like many residential locations, highways, and similar built up areas, most recreational facilities in the project area will be affected the same regardless of which site is developed. Usage of public recreational areas will be increased more during construction, and private recreational facilities will increase membership during operation. Because of the limited number of construction workers expected to relocate to the project area, the many public facilities probably will not be stressed. Hoosier National Forest is expected to receive increased day use, especially for picnicking, hiking, swimming, fishing, and hunting. Visitation to Rough River Dam State Resort Park, with its well developed recreation facilities, is also expected to increase. Because of current intense usage and proximity of this park to the two sites, it likely will receive the heaviest impact from an increased population associated with the project. The possible simultaneous construction of the proposed synfuel plant just south of the Breckinridge site would further increase the impact on all recreation areas and especially Rough River Dam State Resort Park.

Hunting and fishing pressure also will increase with population influx and possibly from daily commuters as well. Greatest impact will be on hunting. Onsite hunting will be greatly reduced due to industrial development of the land. However, hunting is likely to increase along the transmission corridor because transmission line access roads will facilitate entry into wildlife cover locations and because the corridor is expected to attract several game species (see Section 4.3.4). Construction of the corridor and access roads will reduce the extent of wildlife cover which, along with increased hunting, could accelerate game harvest and reduce the quantity and quality of hunting opportunities. Although Kentucky apparently has not experienced excessive hunting pressure because of increased hunter access via rights-of-way, continuing development may eventually cause restrictive hunting regulations in such high-access locations. During construction of the generating station and transmission facilities, poaching will increase, as will harassment of wildlife and other stresses that will affect hunting opportunities during those years. The impact on harvesting furbearers for economic benefit will be similar.

Land uses that will be affected primarily on the site and corridor include agriculture and woodlands. Acreages of each of these land uses will be lost, as will economic benefit derived from such uses. Differences in impacts to these land uses are major site-specific considerations, although impacts to some other land uses also have site-specific implications.

Table 4.1-17. Effects of Development of Hancock Generating Station on Land Use

Land Use and Effect	Significance	Hancock Site Alternative	Breckinridge Site Alternative
AGRICULTURE			
Preemption of present agricultural land use for industrial land use on site.	Essentially irreversible loss of present farmland on site.		
1) Elimination of cropland.	Major impact due to economic value.	Approximate cropland loss, Hancock site = 746 acres.	Approximate cropland loss, Breckinridge site = 1008 acres.
2) Elimination of pasture land.	Minor impact due to limited livestock production.	Approximate pasture land loss, Hancock site = 733 acres.	Approximate pasture land loss, Breckinridge site = 422 acres.
Preemption of present agricultural land use for linear land use on corridors.	Minor impact due to limited disturbance of agricultural land.		
1) Construction of Unit 1 corridor.		Estimated agricultural land, Hancock Unit 1 corridor = 45 acres. Direct usage loss = <1 acre.	Estimated agricultural land, Breckinridge Unit 1 corridor = 126 acres. Direct usage loss = <1 acre.
2) Construction of Unit 2 corridor.		Estimated agricultural land, Hancock Unit 2 corridor = 416 acres. Direct usage loss = <1 acre.	Estimated agricultural land, Breckinridge Unit 2 corridor = 384 acres. Direct usage loss = <1 acre.
Loss of economic value of crops on site over life of generating station.	Major impact due to economic value lost.	Projected annual crop value loss, Hancock site = $241,506.	Projected annual crop value loss, Breckinridge site = $231,173.
WOODLANDS			
Preemption of present woodland land use on site for industrial land use.	Long-term loss of woodland land use in most areas. Permanent loss of woodland land use in some areas.		
Elimination of future timber production.	Major impact due to amount of producing timberland eliminated.	Approximate woodland loss, Hancock site = 690 acres.	Approximate woodland loss, Breckinridge site = 959 acres.
Preemption of present woodland land use for linear land use on corridors.	Long-term loss of woodland land use.		
Elimination of future timber production.	Major impact due to amount of woodlands affected.	Estimated woodland loss, Hancock Unit 1 corridor = 159 acres. Approximate woodland loss, Hancock Unit 2 corridor = 134 acres.	Estimated woodland loss, Breckinridge Unit 1 corridor = 188 acres. Approximate woodland loss, Breckinridge Unit 2 corridor = 99 acres.
WATER RESOURCES			
Disruption of streams and ponds onsite.	Moderate impact onsite. Minimal impact offsite.		
RECREATION			
Increased use of surrounding recreational facilities, especially Hoosier National Forest and Rough River Dam State Park.	Moderate impact due to increased population in area.		
Decreased use of site for hiking and nature study.		Major adverse impact on use of Jeffry Cliff as recreation area due to surrounding construction and restricted access.	
Increased barge traffic on Ohio River.	Minor impact on water skiing, boating, and fishing.		
Decreased fishing potential in nearby streams.			Minor impact to Town Creek during construction due to increased siltation.
Increased game fish in Ohio River where docking facilities are built. Greater number of fish held in the area and available for fishing.	Impact depends on whether KU allows fishing close to docking facilities.		
Decreased hunting onsite and in surrounding area due to loss of wildlife habitat.	Major adverse impact.		
Increased hunting on corridors due to increased hunter access and attraction of game to corridor habitat.	Positive initial impact, but increased game harvest can reduce quantity and quality of hunting opportunities over time.		

Table 4.1-17. Effects of Development of Hancock Generating Station on Land Use (Sheet 2 of 2)

Land Use and Effect	Significance	Hancock Site Alternative	Breckinridge Site Alternative
TRANSPORTATION AND LINEAR USES			
Increase in barge traffic on Ohio River.	No significant impact on river transportation.		
Increased construction of transmission lines.	Minor negative impact on traffic in rural access roads.		
Increased traffic on major access roads to site.	Major impact on congestion of 2-lane U.S. 60.	Major impact on traffic congestion on Kentucky 1406 and at intersection with U.S. 60, compounded by current heavy use as access to Willamette Industries, Kraft Paper Plant.	Major impact on traffic congestion on Kentucky 144 and at intersection with U.S. 60.
Increased rail usage.	Minor impact.		
RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL			
Growth of urban places in surrounding area.	Major impact on local economy – increased construction, housing demand, commercial growth, demand for municipal services.		
Preemption of additional industrial development in the area due to consumption of air increment.		Major impact on reduction of industrial growth.	
ZONING			
Increased development of zoning.	No significant impact.		
MINERAL RESOURCES			
Preemption of mineral resource use on site and corridors.	No onsite mineral resource use. Impact on mineral resource use on corridor dependent on location of transmission line.	Potential impact on coal resources. Moderate potential impact on oil and gas resources.	Minor potential impact or oil and gas resources.

4.1.2.2. Hancock Site Alternative

4.1.2.2.1 Generating Plant

Although the extent of cultivation on the Hancock site is less than on the Breckinridge site, crop value is higher and economic losses projected over the 35-year life of the generating station are greater. Estimated crop value losses for major crops on the Hancock site are $241,506 per year (in 1979 dollars) for the life of the project (see Table 3.1-19). In addition to the elimination of 606 acres of these major crops, 144 acres of hay production will be lost. Livestock production, which is higher on the Hancock site, will be lost on 759 acres of pasture land.

Development of the Hancock site will eliminate approximately 655 acres currently occupied by woodlands. The approximate forest loss by cover type is:

180 acres = lowland hardwoods
475 acres = upland hardwoods
7 acres = conifers

Although a complete timber cruise would be needed to determine the present and projected future value of the woodlands, much merchantable timber is present. A survey of 80 acres of lowland hardwoods identified 236,000 board feet of merchantable timber valued at $12,000 in 1979 (Bowne, personal communication 1980). Timber harvest of this and other woodlands prior to construction will reduce the economic loss. However, continuing timber maturation and future harvest of the woodland will be eliminated.

Recreational use of the Jeffry Cliff area will be deteriorated by adjacent industrial development. Access to the area will be greatly reduced by development, which will surround almost 75% of the Jeffry Cliff ridge. The natural setting will be adversely impacted by the construction of industrial facilities and clearing of adjacent woodlands. Although one industry (Willamette Industries) is already present within view of Jeffry Cliff, it is located on the north side of the cliff, which has limited access and restricted views. Hancock Generating Station development will surround the east and west sides of Jeffry Cliff as well as the north side. The eastern and western sides are primary access routes for hikers, picnickers, nature photographers, and others who visit Jeffry Cliff. The development of the proposed 400-acre regional park at Jeffry Cliff could be considered incompatible with extensive industrial development.

4.1.2.2.2 Transmission System

Unit 1. Extent of land use changes on the Hancock transmission corridor will depend on the exact location of the transmission line. This area is primarily woodland and agricultural land use, with woodlands being predominant (see Figure 3.1-14). In a projected 250-foot wide right-of-way running in a straight line from the Hancock site to the existing Elizabethtown corridor and a projected 150-foot wide right-of-way continuing from that point in a straight line to the existing Owensboro corridor southwest of Victoria Crossroads, approximately 78% (159 acres) of the land use is woodland and 22% (45 acres) is agricultural. This appears to be a fairly representative estimate of the proportions of woodland and agricultural land use on this corridor.

Agricultural areas are expected to receive little impact from construction of the transmission system. Only the 31 square-foot area occupied by each tower (see Subsection 1.3.3.1) will be removed from cultivation, and crop production and grazing around the tower is not precluded. If 22% of the 50 towers estimated for Unit 1 transmission are on agricultural lands, then less than 1 acre will be occupied by towers.

Woodlands, however, will receive greater impact, not only because they are more extensive, but also because they will be disturbed along the entire length of the right-of-way in the woodland areas. Cutting and clearing of vegetation will remove all of the estimated 159 acres of woodland land use on this corridor. Trees of commercial value will be harvested, but future timber production is eliminated.

Because they are more abundant along the Hancock corridor, mineral resources are more likely to be impacted there than on the Breckinridge corridor, although careful routing will reduce this possibility. Coal-bearing formations cover most of this portion of Hancock County (see Figure 3.1-10), and oil and gas pools in the Dukes School (see Figure 3.1-11) are in the path of the proposed corridor.

Unit 2. Since 76% of the land use on the Elizabethtown corridor is agricultural (see Figure 3.1-18), widening of this corridor will have little impact on land use. Of the 416 acres in agricultural use, less than 1 acre is estimated to be occupied by additional towers.

Approximately 134 acres of woodlands will be eliminated when the corridor is widened. The only extensive areas of woodlands on this corridor are between the Hancock corridor and a point southeast of cloverport and between the communities of Locust Hill and Custer. Most of the woodland land use that will be eliminated is scattered in small isolated tracts.

4.1.2.3 Breckinridge Site Alternative

4.1.2.3.1 Generating Plant

Preemption of agricultural and woodland land uses for industrial development is also a major impact on the Breckinridge site, with crop value losses estimated at $231,173 per year (in 1979 dollars) for the life of the project. The economic losses are about $10,000 less than on the Hancock site, even though more acres are cultivated on the Breckinridge site. This is primarily due to a lower production rate and lower price for soybeans, a lower price for corn, and fewer acres in tobacco, compared with the Hancock site (see Table 3.1-19). Approximately 226 acres of hay added to the 782 acres of these major crops makes a total of 1008 acres of cultivated farmland that will be eliminated by construction of the generating station -- 258 acres more than on the Hancock site.

Most of the 959 acres of woodlands on the Breckinridge site are upland hardwoods. The approximate woodland loss by cover types is:

58 acres = lowland hardwoods
901 acres = upland hardwoods

The number of acres of lowland hardwoods is less than one-third that on the Hancock site, while the acreage of upland hardwoods is 426 more. As on the Hancock site, the approximate timber value of the Breckinridge forest would need to be determined by a timber cruise. However, per unit production likely is lower on the Breckinridge site than on the Hancock site because of relatively recent extensive disturbance associated with timber harvesting. Not only are the stands less mature, but because of effects of disturbance on soils, less than optimal growth conditions exist.

Recreational use of Town Creek embayment for fishing and swimming may be reduced due to increased congestion and activity during the construction phase. However, reduced usage is expected to be temporary, and the large number of fishing areas nearby makes this a fairly insignificant impact.

4.1.2.3.2 Transmission System

Unit 1. Projected location of transmission right-of-way of widths as described for the Hancock right-of-way indicates that the Breckinridge corridor from the site to the Owensboro corridor west of McQuady will traverse land that is approximately 60% woodland and 40% agricultural. Due to the greater length of the Breckinridge corridor, more acres of woodlands (188 acres) and agricultural areas (126 acres) will be affected than on the Hancock corridor. Based on these estimates and tower placement estimates, less than 1 acre of agricultural land will be lost in addition of 188 acres of woodlands.

Selective routing, however, can put much of this corridor in agricultural lands, reducing the amount of woodlands disturbed. Numerous north-south agricultural expanses interspersed with woodlands allow greater avoidance of woodlands than on the Hancock corridor, where woodland areas are more extensive, and agricultural expanses are more limited and predominantly east-west in alignment (see Figure 3.1-17). As on the Hancock corridor, future timber production will be eliminated on the woodlands cleared for the corridor.

Major coal-bearing formations are not extensive in Breckinridge County (see Figure 3.1-10) so this mineral resource will not be affected. Although numerous gas and oil pools (see Figure 3.1-11) are located on the western and southern edges of the potential corridor route, it is doubtful if the right-of-way will pass through these areas.

Unit 2. Upgrading of the Elizabethtown corridor for the Breckinridge alternative will eliminate widening of the corridor between the Hancock and Breckinridge corridors, reducing the impact on land use. This reduction of approximately 67 acres includes one of the larger woodland expanses along the corridor. Thus, 35 fewer acres of woodlands will be disturbed.

4.1.3 Cultural Factors

The primary impact on cultural factors will be alteration of the present rural setting and disturbance of the physical and historical aspects of that setting. Due to the long-term commitment of land resources for the generating station, the transformation to an industrialized setting will have an essentially permanent effect on the visual, historic, and archaeological integrity of the site.

4.1.3.1 General Effects on Visual Resources

Vegetation clearing, land grading, presence of generating station structures and facilities, filling of ravines with solid waste, and construction of transmission lines will change the visual character of the site and the surrounding area. Although some industrial presence is existing on one site and proposed on the other, the predominant visual character of the region is a rural agrarian landscape. Construction of the generating station is not compatible and will cause a general degredation of existing visual quality.

The height and size of the cooling towers, stacks, and boilers will be out of proportion with the relatively level, low-lying terraces on which they will be built. The white, moisture-laden plumes from the cooling towers will be visible from a distance. Docking and unloading facilities and barges will dominate portions of the view from the Ohio River and from Indiana. Existing topography and vegetation patterns, which are integral to the present visual character, will be drastically altered and/or eliminated.

4.1.3.1.1 Hancock Site Alternative

4.1.3.1.1.1 Generating Plant

Development of either the Hancock or Breckinridge sites will alter the character and reduce the visual quality of the area. On the Hancock site, the rolling topography of the northern portion will be leveled, while hills and ridges in the southern portion of the site will be cleared of forest cover, the ravines filled, and grasses and other herbaceous cover established. These actions essentially eliminate the contrasting land forms and vegetation patterns that give the site high aesthetic value. The visibility of the uplands near Jeffry Cliff increases the impact of landfill operations.

However, plant structures will be less visible and the size of the structures will have less contrast in scale due to the rolling topography and background ridges, including Jeffry Cliff.

Jeffry Cliff, which is the most unique landform on either site, is probably the major factor in the visual character of the Hancock site. Although the cliff itself will not be disturbed by construction, alteration of the surrounding land will produce an incompatible visual contrast and reduce its quality as a vivid and harmonious focal attraction. Development of an industrialized setting around much of the ridge further reduces its natural character.

Although the presence of the pulp and paper mill adjacent to the site detracts from the present visual unity of the area, most of the site still retains a rural agrarian character. The existing topography limits the view of the Willamette facility, although its plume is visible over much of the Hancock site. Construction of the Hancock Generating Station will be visually compatible with existing nearby industry, yet incompatible with the existing landscape on the site and in the area.

The Hancock site is more sensitive to reduced aesthetic quality than is the Breckinridge site, because the viewshed and the viewer population are greater. Various aspects of the site are visible from Indiana Route 66, across the river, and U.S. Highway 60 in Kentucky, both of which are well-traveled roads. Scenic overlooks just east of Hawesville also view the site. The Hancock site is closer to population centers, especially Hawesville and Cannelton, and to the only bridge in that area that crosses the Ohio River, making the potential viewer population large.

4.1.3.1.1.2 Transmission System

Unit 1. The greatest visual impact from the Hancock transmission system will be in wooded areas. Corridor visibility is greatest on woodland slopes where there is a marked contrast between the low vegetation of the corridors and the surrounding forest. The extensive woodlands on the Hancock corridor increase the possibility of this negative impact.

The viewshed of the corridor, however, will be relatively small due to limited access roads. Thus, although the visual impact will probably be greater on the Hancock corridor, the disturbance will be viewed by fewer people.

Unit 2. Since this corridor is existing, the 100-foot widening will not appreciably affect visual quality of the landscape, even where woodlands are cleared. The major negative impact from construction of Unit 2 will be the visual incompatibility of two different types of towers along this corridor. The existing line generally has wooden H-frame towers (see Figure 3.1.28), and the new line will use 138-foot-tall, steel-framed double-circuit towers required by higher voltage (see Figure 1.3-20). This will create a significant visual contrast.

4.1.3.1.2 Breckinridge Site Alternative

4.1.3.1.2.1 Generating Plant

Reduction of the visual quality on the Breckinridge site will be similar to that on the Hancock site. Construction and operation procedures will alter the topography and vegetation patterns as well as the rural character of the site. The limited visibility of the uplands on this site reduces the impact on landfill operations, but the fairly level terrain in the vicinity of the generating station facilities will increase visibility of those structures.

The Breckinridge site currently has no industrial facilities in the area to disturb its visual unity. The presence of numerous structures formerly associated with the Corps of Engineers dam at Addison does not fit the agrarian character of the rest of the site, but their abandoned state amd small scale minimizes the contrast. The possible development of a synfuel plant adjacent to the site, however, would be large scale and would significantly reduce the visual integrity of the area. This situation would be similar to the existing industry at the Hancock site. Still, in both instances, development of the generating station would be in contrast to the existing rural setting of the region.

The Breckinridge site has a smaller viewshed and fewer potential viewers than the Hancock site. On the Indiana side of the river, only the few residents along a dead-end secondary road have a view of the site. No main highways in Indiana are close enough for the site to be visible. On the Kentucky side, U.S. 60 is well out of view of the site. Only Kentucky Route 144 traverses the site, and traffic on this road is generally light (see Table 3.1-13). The distance from Cloverport and the hamlet of Stephensport make the potential viewer population low.

4.1.3.1.2.2 Transmission System

Unit 1. As on the Hancock corridor, the greatest visual impact will be in areas where the transmission line cuts through woodlands. The greater presence of agricultural lands on the Breckinridge corridor increases potential for avoidance of woodlands and lowers the extent of negative visual impact.

However, the more open, agricultural landscape and the increased road access make the viewshed and the viewer population larger. Thus, the visual impact will be lower, but the visibility will be higher.

Unit 2. Visual impacts for the Breckinridge alternative of Unit 2 will be similar to those in the Hancock alternative.

4.1.3.2 General Effects on Archaeological Resources

Archaeological resources, like historical resources, are nonrenewable. The impacts of disturbing archaeological and historical resources range from direct destruction of specific sites to changes in the integrity of the setting or feeling of the property that contributes to its significance (36 CFR 800). Other possible adverse effects include isolation of the site from the surrounding environment; introduction of out of character visual, audible, or atmospheric elements; neglect; or transfer or sale of the property without adequate preservation restrictions.

Evaluation of the project area's archaeological and historical resources, as well as assessment of impacts, is based on criteria defined in 36 CFR 800. Each of the cultural sites will be indirectly affected by land modification activities in the area, with the predominately rural character of the area changed to an industrial setting. Construction of buildings, roads, pipelines, and docks on the plant site will disturb archaeological sites on lowland areas and along the Ohio River, while landfills will alter those sites in uplands. Because of extensive preconstruction evaluation and salvage of known sites and instructions to work crews to report undiscovered sites, loss of unknown sites is not expected.

Photographs and descriptions of archaeological sites and artifacts that may be affected by construction of the generating station are on file with the Kentucky Heritage Commission. The Kentucky State Historic Preservation Officer (SHPO) has requested a cultural survey of either the Hancock or Breckinridge transmission corridor when the centerline has been located, so that cultural resources along the two corridors are not included in the following discussion of the two alternatives. Similarly, the Kentucky SHPO has determined that an archaeological survey of the Elizabethtown corridor will be necessary prior to constructing the Unit 2 line, so that impacts on historic resources only are discussed for that corridor.

4.1.3.2.1 Hancock Site Alternative

The Kentucky Heritage Commission has recommended testing 33 archaeological sites on the Hancock site (5 of which are now believed to be outside the site boundaries) to determine if they are eligible for inclusion in the National Register of Historic Places. This evaluation will involve systematic test-excavation of alluvial and eolian deposits on lower and upper terraces to determine the extent and nature of known sites and to locate any geologically sealed deposits (University of Kentucky 1980).

Seven of these potential National Register archaeological sites are in locations where facilities are proposed (see Figures 1.3-2 and 3.1-30): 15HA124 is the location of pond C; 15HA131 is in the main facilities area; 15HA138 is by the cooling tower location; 15HA144, 15HA146, and 15HA152 are within the cooling tower make-up pipeline and blowdown pipeling right-of-way; and 15HA156 is at the bridge and access road to the barge unloader. Eight of the archaeological sites are in locations to be used during landfill operations: 15HA111, 15HA114, 15HA116, 15HA117, 15HA118, 15HA180, 15HA181, and 15HA182. The remaining sites possibly would be affected by construction activities in general and/or landfill activities.

4.1.3.2.2 Breckinridge Site Alternative

On the Breckinridge site, 5 archaeological sites have been recommended by the Kentucky Heritage Commission for further testing to determine National Register eleigibility. The portion of the Breckinridge site that has not been surveyed (see Sections 3.5. and 5.3) will be surveyed prior to site permitting to determine if there are any additional sites with National Register potential (Kentucky Heritage Commission, personal communication 1980). Testing procedures for recommended sites will be the same as those described in the Hancock alternative.

Four of the potential National Register sites are in locations where facilities will be constructed (see Figures 2.1-3 and 3.1-35): 15BC90 is near the SO_2 removal equipment; 15BC93 is in the area of the inactive coal pile; 15BC99 is in the area of the coal and limestone barge unloading facilities; and 15BC19 is in the area of the inactive coal pile, limestone diverter house, stockout pile, and transfer house. The remaining site is on the Ohio River and, although near the barge facilities, is less likely to be directly affected by construction activities.

4.1.3.3 General Effects on Historic Resources

As mentioned above, the historical resource effects assessment was based on criteria defined in 36 CFR 800. The Indiana SHPO has determined that three structures across the Ohio River and in view of the Hancock site are eligible for nomination to the National Register of Historic Places. One structure across the Ohio River and in view of the Breckinridge site also has been determined eligible for nomination to the Register. The Indiana SHPO has evaluated the proposed action and potential effects on these structures and has determined that there will be no adverse impacts on them from development of either site. In accordance with 36 CFR 800, EPA completed nomination forms for these structures and initiated consultation with the Keeper of the National Register of Historic Places.

4.1.3.3.1 Hancock Site Alternative

The Kentucky SHPO has determined that none of the historic sites surveyed on the Hancock site is eligible for nomination to the National Register of Historic Places.

Two cemeteries, Lake Cemetery and Flake Cemetery, are located in one of the landfill areas. The Younger-Brashear Cemetery is near the main facilities area (see Figures 1.3-2 and 3.1-31).

4.1.3.3.2 Breckinridge Site Alternative

The Kentucky SHPO has determined that none of the newly surveyed structures on the Breckinridge site is eligible for nomination to the National Register, although two structures on the site already are on the Register: the Holt Chapel and the Holt House. The Holt Chapel, which is deteriorated, is likely to be affected by general construction near the SO_2 removal equipment (see Figures 2.1-3 and 3.1-36). The Holt House, which is in poor condition, is not likely to be directly affected by construction, although its location on Highway 144 makes it subject to impacts from increased traffic, noise, and fugitive dust.

All of the three cemeteries on the Breckinridge site are located near areas of construction activities, with possible impacts related to the extent of nearby disturbance (see Figures 2.1-3 and 3.1-40). A slave cemetery is adjacent to the access road to the makeup pump house, the Burk-Stephens cemetery is near a landfill area, and Holt Cemetery is on Highway 144, which will be the main access to the site.

4.1.3.3.3 Elizabethtown Transmission Corridor

The Kentucky SHPO has determined that one of the structures surveyed along the Elizabethtown corridor, the Stamper Pirtle House, is eligible for nomination to the National Register. A second structure, the Pirtle-Klinglesmith House is a designated Kentucky landmark. These structures are located less than one mile apart on highway 86 in Howe Valley. The Stamper Pirtle House is roughly 300 feet south of the existing transmission corridor and will be subjected to short-term increased fugitive dust, traffic, and noise during construction. For the long-term, the addition of another transmission line (especially one that will create an adverse visual contrast with the existing line) will intensify the aesthetic impact on its viewshed. The Pirtle-Klinglesmith House would be affected similarly but somewhat less due to its greater distance (roughly 1100 feet) from the corridor.

4.2 ATMOSPHERE

The major atmospheric elements affected by the project include meteorology, air quality, and noise. Most impacts associated with these elements will be restricted to the area surrounding the plant site.

4.2.1 Climate and Meteorology

Changes in the climatological and meteorological conditions due to development of the generating station will be primarily caused by emissions and heat released from the boiler chimneys and by moisture and carry-over released from cooling tower operations. Construction activities may have slight short-term effects on atmospheric conditions. All atmospheric effects will be most evident on the plant site. With the exception of fogging and icing potential adjacent to the Hancock site, significant adverse impact is not expected from either chimney or cooling tower releases, and the releases are not expected to interact because of the differences in chimney and cooling tower heights.

4.2.1.1 General Effects on Atmospheric Conditions

Chimneys. In large fossil-fueled steam electric generating stations, about 10% of the heat input to the boiler is lost through boiler stack emissions. A typical 400-MW plant emits about 100 MW of sensible heat and generally a quantity of latent heat equivalent to the power generated (Old West Regional Commission 1977). At a wind speed of about 30 feet/second, the sensible heat from a 400 MW plant could raise the temperature of the lowest 0.5 mile of atmosphere by only 0.002°C in an area about 3 miles wide. This quantity of sensible heat is negligible relative to the energy needed to affect precipitation formation. According to the Commission study, the quantity of sensible heat associated with a plant 10 times larger (4000 MW) would remain of negligible influence in precipitation processes. The effects of the latent heat also are unexpected to be negligible, except in relation to a quite small convective cloud formation directly over the plant.

Also associated with the boiler operation are airborne releases of fine particulate matter, sulfur dioxide, and nitrogen oxides. The fine particulate matter emitted from the 600-foot stacks has the potential to affect precipitation processes via altering the microphysical nature of clouds rather than by changing the dynamical processes producing clouds as does heat and water vapor. (Old West Regional Commission 1977). The relationship of microphysical structure and precipitation formation is not entirely understood, but known factors indicate power plants of similar capacity to the Hancock station cause only minor increases or decreases in precipitation amounts. The changes, if any, are caused by addition to the atmosphere of particulates that are cloud condensation nuclei (CCN) or, in rarer instances, ice nuclei. When a cloud forms, the condensation occurs on a class of particles called cloud condensation nuclei; similarly ice particles in clouds originate as a result of the action of a class of particles that are ice nuclei. The addition of either type of particle to the atmosphere could either decrease or increase precipitation, depending on how many are already present and how many are added; the mechanisms of ice nuclei are less known than those of CCN. Sufficient CCN concentrations from a 1000 MW have been recorded to indicate small precipitation effects in a limited area downwind of the plant, but the magnitude of effects was not sufficient to be comparable to annual variability in precipitation.

The emissions of sulfur dioxide and nitrogen oxides can lead to the formation of acidic sulfates and nitrates in rainwater. Normal precipitation is naturally acidic (pH 5.6 to 5.7) because of the reaction of water with atmospheric carbon dioxide; however, research based on 20 years of records (EPA 1980) has indicated that average precipitation in most states east of the Mississippi River now lies between pH 4 and 5. The primary cause of the decrease in precipitation pH is increased use of fossil fuels by industry (especially power plants) and automobiles (EPA 1980). The further increase in acidic precipitation levels due to emissions from the proposed project and similar ones in the area likely will be greatest outside the project area because of the chimney height, plume trajectory, and prevailing wind patterns. However, the project area is being affected similarly by emissions from other sources.

The degree and extent of precipitation pH effects attributable to KU's proposed plant cannot be calculated with existing evaluation techniques. However, the high-efficiency emissions control equipment proposed for the plant will limit pollutants to low levels, so that the plant's contribution to overall changes in precipitation pH will be small. Impacts associated with precipitation acidity include decreased pH in surface waters and soils and effects on sensitive vegetation. Correlating such impacts with increased precipitation pH also is difficult. Areas in North America where increased acidification due to excessive acidity in precipitation has been reported in recent years are eastern Canada and northeastern United States (Central Electricity Research Laboratories 1979). Increased acidity in surface waters also has been reported in Florida and other parts of the southeastern United States; however, a direct relationship with increased acidity in precipitation has not been confirmed in these locations.

Cooling Towers. Mechanical draft cooling towers proposed for the project will release plumes of water vapor and condensation droplets. Drift droplets containing small amounts of dissolved solids present in the generating station's circulating water also will escape into the atmosphere. The moisture-laden plumes will affect atmospheric conditions, while the drift, which will fall out of the atmosphere, may affect soil conditions and vegetation. Significant effects, if any, from either emission are expected to occur only near the cooling towers.

Changes in atmospheric conditions associated with the cooling tower plumes include increases in fogging and icing occurrences at ground level. Conditions for fogging and icing typically result from strong winds (typically those exceeding 7 to 11 miles per hour) that produce aerodynamic downwash of the plumes, high ambient relative humidity, and relatively low ambient temperatures. Plume downwash occurs somewhat less than 50% of the time for cooling towers located in the mid-eastern United States. Natural fog, which is caused by similar meteorological conditions as the plume-induced fog, occurs frequently in the project area but is severe (visibility restricted to 0.25 mile or less) about 14 days a year (see Table 3.2-6). October, December, and January generally have about one-half of the severe fog days, so that conditions inducing icing (ground level fog and subfreezing temperatures) may occur nearly as frequently as those inducing severe fogging. Most of the ground level fogging and icing attributable to the cooling towers will occur within 600 to 1000 feet of the structures, within the aerodynamic cavity of the towers (Hanna 1975, Ryznar 1977). Once past this cavity, the plume will lift because of strong bouyant forces in the plume.

Drift droplets from the cooling towers typically contain calcium, magnesium, sodium, carbonates, chlorides, and sulfates. The mechanical draft system proposed for the KU plant will emit drift solids at a rate of about 2 grams per second during maximum load. This rate is based on about 250,000 gpm circulating water flow per generating unit (see Figure 1.3-5 and Table 1.3-6), a maximum total dissolved solids content of 3343 milligrams per liter, and a maximum drift rate of 0.002%. The major ions in these drift solids will be calcium, sodium, and sulfates. Recent but limited data on deposition rates (Davis and Moon 1978; Meyer and Stanboro 1978; Rochow 1978; Laulainen et al. 1979) indicate that the KU cooling towers can be expected to produce localized short-term deposition (during maximum load) of total drift solids on the order of 130 milligrams per square meter-hour (9 square feet-hour) within 50 meters (150 feet) of the towers. At distances of 100 to 500 meters (300 to 1500 feet), the deposition rate will decrease to 6 milligrams per square meter-hour.

Long-term average deposition rates, which will reflect normal operating capacity of the generating station, are expected to be a small fraction of the maximum short-term deposition rates. Conservative estimates of average deposition of total drift solids are 9000 kilograms per square kilometer-month (25 tons per square mile-month) within 50 meters, and 400 kilograms per square kilometer-month (1 ton per square mile-month) within 100 to 500 meters. In similar geographic locations, models have indicated drift deposition rates of approximately 3400 kilograms per square kilometer-month (9 tons per square mile-month) at a distance of 900 meters (2700 feet) (Roffman and Van Vleck 1974), and 5600 kilograms per square kilometer-month (16 tons per square mile-month) at a distance of about 200 meters (600 feet) (Public Service Company of Indiana 1975). Both of the published estimates are higher than those predicted for Hancock Units 1 and 2. The deposition rate estimated to occur within 150 feet is greater than Kentucky's settleable particle standard (3-month average of 15 tons per square-mile month). In closest offsite locations, however, average deposition is predicted to be well below that amount.

Construction. Construction activities on the site will cause emissions of fugitive dust and windblown matter to become airborne. The airborne particulate matter has the potential to increase the number of cloud condensation nuclei and thus enhance cloudiness during the 12-year construction period. The possibility of significant cloudiness and changes in precipitation is negligible and no impacts are anticipated. One study suggests, however, that fugitive dust has greater potential to alter precipitation processes than does suspended particulate matter from the chimney's (Old West Regional Commission 1977).

Land clearing during construction has the potential to alter the radiation balance on the site by creating increased reflection of solar radiation. Currently vegetated areas absorb the radiation. Increased radiation will tend to increase surface temperatures during the daytime and lower temperatures at night. The resultant convection patterns have the potential to alter surface wind patterns over the affected areas. The changes in wind patterns are expected to be slight and impacts will be negligible.

Construction impacts, although slight, could be expected to occur over a 12-year period beginning in summer 1982. The impacts will be localized in an area centered on the construction site. They will be lessened by the Applicant's plans to wet down unpaved roads and parking lots, control traffic flow, and revegetate exposed areas. Clearing and revegetation will continue throughout the life of the plant in areas designated for landfill. This clearing will be on a smaller scale (25 acre increments) than initial site clearing and meteorological impacts are expected.

4.2.1.2 Hancock Site Alternative

Meteorological impacts attributable to chimney emissions and construction activities will not differ significantly on the Hancock and Breckinridge sites. Potential impacts attributable to cooling tower emissions could differ, however, based on the proximity of the cooling towers to public roadways and other offsite areas and the prevailing meteorological patterns.

On the Hancock site, plume-induced fogging or icing will occur frequently on Skillman Road and the adjacent Louisville and Nashville Railway switchyard at locations north of the cooling towers (see Figure 1.3-2). Predominant winds are southerly and southwesterly (see Figure 3.2-2 and Subsection 3.2.1.2.4). Due north, the rights-of-way are within 400 and 900 feet respectively of the Unit 2 cooling tower; in a northeast direction, both are within 1200 feet of the Unit 2 cooling tower. Natural fogging that is severe enough to restrict visibility generally occurs shortly before sunrise when temperatures are lowest, so that early morning travelers and train operations probably will experience greatest reduced visibility from occasional severe fogging and icing induced by the cooling tower plumes.

No other offsite locations are expected to have reduced visibility due to the cooling tower plumes. Plume-induced fogging on the Ohio River would be minor at either site and plume-induced icing at the river is not expected.

4.2.1.3 Breckinridge Alternative

On the Breckinridge site, no offsite locations are within 1000 feet of the cooling towers. The cooling tower is 1000 feet northeast of the site's southern boundary at a point where the boundary is an unpaved, property access road (see Figure 2.1-3). Predominant winds are southerly and easterly (see Figure 3.2-2 and Subsection 3.2.1.2.4), so that most fogging and icing due to the cooling towers should be in the direction of the generating station facilities and holding ponds. In the predominant wind directions, the cooling towers are at least 3000 feet from highway 144. Lower average wind speeds on the Breckinridge site (average of 3.9 mph vs. 5.1 mph on the Hancock site) indicate lower potential for plume-induced fogging and icing.

4.2.2 Air Quality

4.2.2.1 General Ambient Air Quality Effects

Ambient air quality of the project area will be affected by pollutants emitted from the boiler chimneys, auxiliary boiler chimney, and cooling towers discussed in Section 4.2.1, and by fugitive dust/windblown emissions from the coal/limestone handling systems and general construction activities.

The boilers for the proposed generating station are rated for a net electric generating capacity of 650 MW with a maximum heat input to the boiler of 6,650 million Btu per hour. Typical heating value of the coal to be fired is 10,500 Btu per pound. The maximum sulfur content of the coal will be 3.5 to 3.7%, maximum ash content will be 14.5%, and maximum coal consumption will be 317 tons per hour. Chimney heights will be 600 feet above grade; the flue gas exist velocity will be 90 feet per second; the chimney diameters will be 290.4 inches; and the flue gas exit temperature will be 170°F.

On both sites, the proposed boiler chimney emissions will meet applicable EPA standards of performance for new major stationary sources. These new source performance standards (NSPS) will be met by installation and operation of a flue gas desulfurization (FGD) system to remove sulfur dioxide (SO_2) from the flue gases at an appropriate efficiency (91.8% at the Hancock site, 90.5% at the Breckinridge site) and the installation and operation of an electrostatic precipitator system that will remove particulate matter from the flue gases at an efficiency of 99.78%. The NSPS for nitrogen dioxide (NO_2) will be met by installation of a boiler designed with adequate residence time and temperature to ensure compliance with the nitrogen dioxide emission standard.

Emissions from the auxiliary boiler also will be within allowable limits for liquid fuels. Estimated SO_2 content of auxiliary boiler exhausts is 0.52 lb/million Btu, and particulates will be in trace amounts. These emissions will be infrequent, occurring only to supplement start-up steam requirements when both units are shut down.

Another source of emissions will be fugitive dust resulting from the operation of the coal/limestone barge unloading, transfer, and storage system. The barge unloading system will be self cleaning with chute work at transfer points designed to keep material dribble from accumulating. Belt cleaning devices will be doubled at critical points, and empty conveyors will be operated for a given time to allow maximum belt cleaning. Windblown particulate emissions from the open coal storage area will be reduced by regularly compacting and wetting the coal pile. The active coal pile will be in silos to reduce the amount of particulate matter that becomes airborne. The coal/limestone handling system will have parallel fabric bag dust filters at all transfer points in the conveyor systems. Areas such as transfer routes from inactive to active storage areas will be water-sprayed as necessary to control windblown coal dust.

During the construction phase of the generating station and transmission system, fugitive particulate emissions can be expected from grading, clearing, facilities placement, wood burning, and vehicular traffic. All burning will be conducted in accordance with applicable air quality regulations. Dust control during the construction phase of the generating station will use 22,000 gallons of water per day at maximum demand. Water will be sprayed on exposed excavations, unpaved roads, parking lots, and structural fills as necessary. Haul material will be sprayed or covered as necessary to reduce airborne particulate matter. To further reduce particulate emissions on the plant site, a transportation plan will be in effect to avoid congestion, encourage car pooling, use designated parking areas, and use clearly marked entrance and exit roads. To reduce pollutant emissions from vehicles, contractors will be required to use appropriate equipment and maintenance procedures for specific model years, fuel, and weight combinations in accordance with 40 CFR 85.

4.2.2.2 Hancock Site Alternative

4.2.2.2.1 Generating Station

The emissions control equipment proposed for the Hancock plant is expected to meet air quality standards at the Hancock site (and Breckinridge site) (Table 4.2-1). The plant will consume a significant portion of PSD increments in localized areas on and adjacent to the sites, but the Class II PSD increment standards will not be exceeded by the plant or due to the plant's interaction with other major point sources. There will be no impact on the nearest Class I air quality area (Mammoth Cave) nor on the nearest non-attainment area (Owensboro, Kentucky).

The plant on the Hancock site will consume 42% of the allowable 3-hr Class II SO_2 increment and 35% of the 24-hr Class II SO_2 increment. The maximum 3-hr SO_2 increment consumption is expected to occur in a localized area near the southern border of the site west of Jeffry Cliff (Figure 4.2-1). Offsite 3-hr SO_2 increment consumption will be 20% of allowable in adjacent locations to the north, including the Ohio River and Hoosier National Forest, and to the south, including portions of Jeffry Cliff (Figure 4.2-1). Five to 10% of allowable 3-hr SO_2 increment will be consumed in outlying locations in Hancock County and several surrounding counties (Figure 4.2-2). The greatest 24-hr SO_2 increment consumption will occur in a localized area on the Ohio River west of the site (Figure 4.2-3). Twenty-percent consumption of 24-hr SO_2 increment will occur in relatively extensive adjacent locations in virtually all directions from the site (Figure 4.2-3). Five to 10% of allowable 24-hour SO_2 increment will be consumed in several surrounding counties (Figure 4.2-4).

Estimated short-term impacts on SO_2 levels due to interaction between the plant on the Hancock site and other new major point sources of emissions show greatest concentrations resulting from interaction of the Hancock plant and the Rockport Generating Station, which will be downriver from the Hancock site. The maximum predicted 3-hour average SO_2 concentration due to this interaction is 180 $\mu g/m^3$ at a point about 0.9 miles east of the Hancock facility. The predicted maximum 24-hour ground-level SO_2 concentration is 27 $\mu g/m^3$, reflecting interaction with the Rockport plant at a point 1.8 miles east of the Hancock plant.

Predicted short-term interactions between the plant on the Hancock site and new and existing major point sources are greatest when the proposed plant and Big Rivers Electric Power Company Coleman Station (8 miles west) are modeled simultaneously. The predicted maximum combined 3-hour SO_2 concentration for all point sources is 694 $\mu g/m^3$ at a point 0.6 miles southeast of the Hancock plant. The estimated maximum combined 24-hour SO_2 concentration is 51 $\mu g/m^3$ at a point 0.6 miles east-southeast of the Hancock plant.

Long-term impacts predicted on regional SO_2 levels due to combined point sources and the Hancock plant are maximum annual SO_2 and TSP concentrations of 41 $\mu g/m^3$ and 0.6 $\mu g/m^3$. Maximum SO_2 concentrations will occur at a point about 8 miles northwest of the Hancock plant.

Table 4.2.-1. Maximum PSD Increment Consumption and Air Emissions on the Hancock and Breckinridge Sites and Comparisons to NAAQS, PSD, and NSPS

		PSD				
			Increment Consumed ($\mu g/m^3$)		% of Allowable	
	Time Period	Allowable PSD Increment Consumption ($\mu g/m^3$)	Hancock Site	Breckinridge Site	Hancock Site	Breckinridge Site
Sulfur dioxide	3 hr	512	214	242	42	47
	24 hr	91	32	39	35	43
	Annual	20	2	2	10	10
Particulates (chimney)	24 hr	37	2	2	5	5
	Annual	19	<1	0.1	0.5	0.5
Particulates (chimney and fugitive)	24 hr	37	32	-	86	-
	Annual	19	2	-	5	-

	NSPS				
		Maximum Project Emissions (lb/hr)		Maximum Project Emission Rate ($lb/10^6$ Btu)	
	New Source Performance Standard	Hancock Site	Breckinridge Site	Hancock Site	Breckinridge Site
Sulfur dioxide	90% removal for controlled emissions; between 0.6 and 1.2 $lb/10^6$ Btu	3,637	4,400	0.54	0.66
Particulates	0.03 $lb/10^6$ Btu	172	172	0.03	0.03
Opacity	20%	<20%	<20%	-	-
Nitrogen dioxide	0.6 $lb/10^6$ Btu	3,990	3,990	0.6	0.6

	NAAQS			
			Consumption at Point of Maximum Interaction of All Sources ($\mu g/m^3$)	
	Time Period	Allowable NAAQS ($\mu g/m^3$)	Hancock Site	Breckinridge Site
Sulfur dioxide	3 hr	1300	694	372
	24 hr	365	51	57
	Annual	80	41	2

Source: Kentucky Utilities Company (1981).

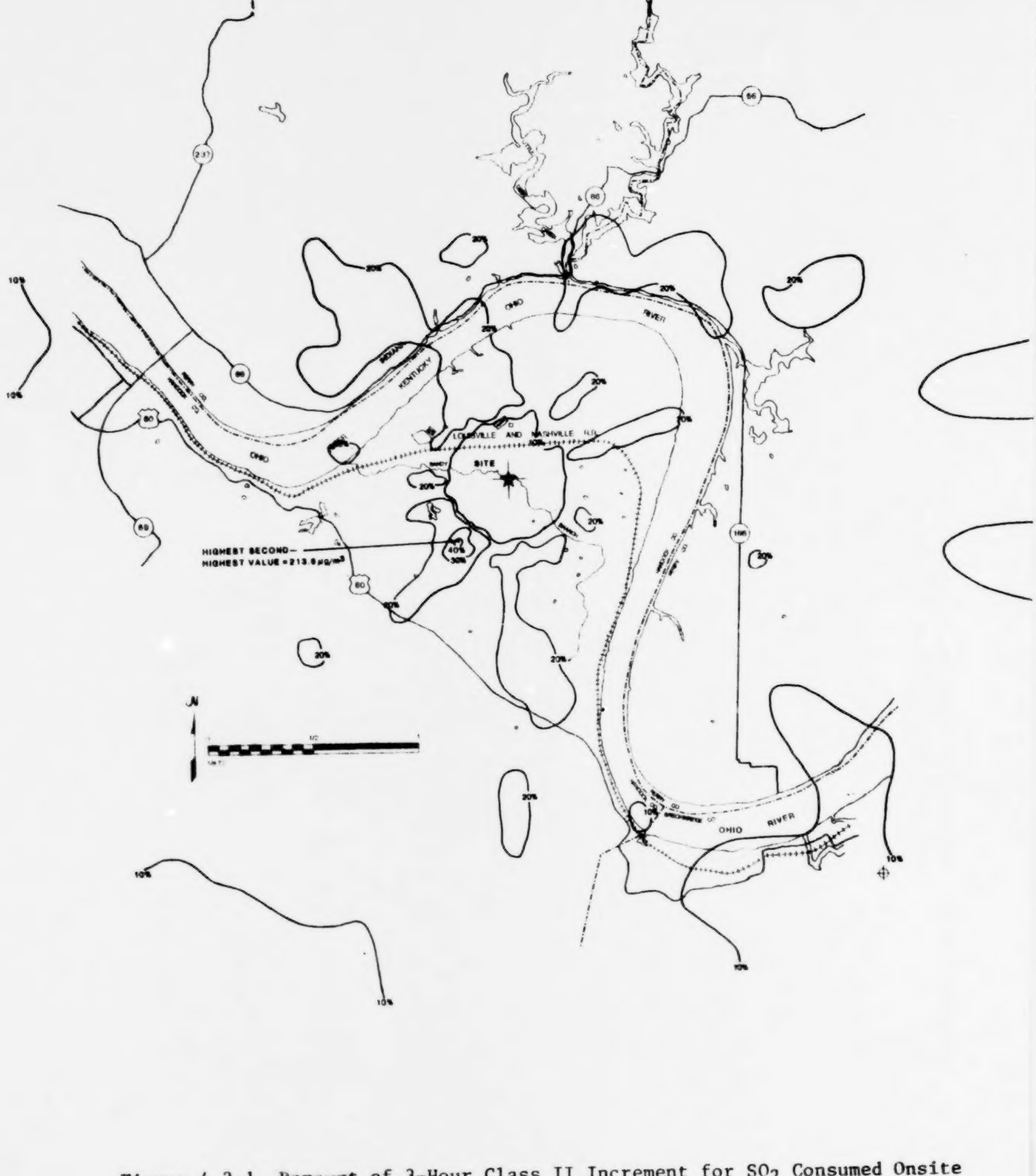
237
66
66
60
60
69
166
10%
20%
30%
40%
OHIO
RIVER
KENTUCKY
LOUISVILLE AND NASHVILLE R.R.
SITE
HIGHEST SECOND—
HIGHEST VALUE = 213.6 µg/m³
N
1/2
1

Figure 4.2-1 Percent of 3-Hour Class II Increment for SO_2 Consumed Onsite by Hancock Generating Station Units 1 and 2

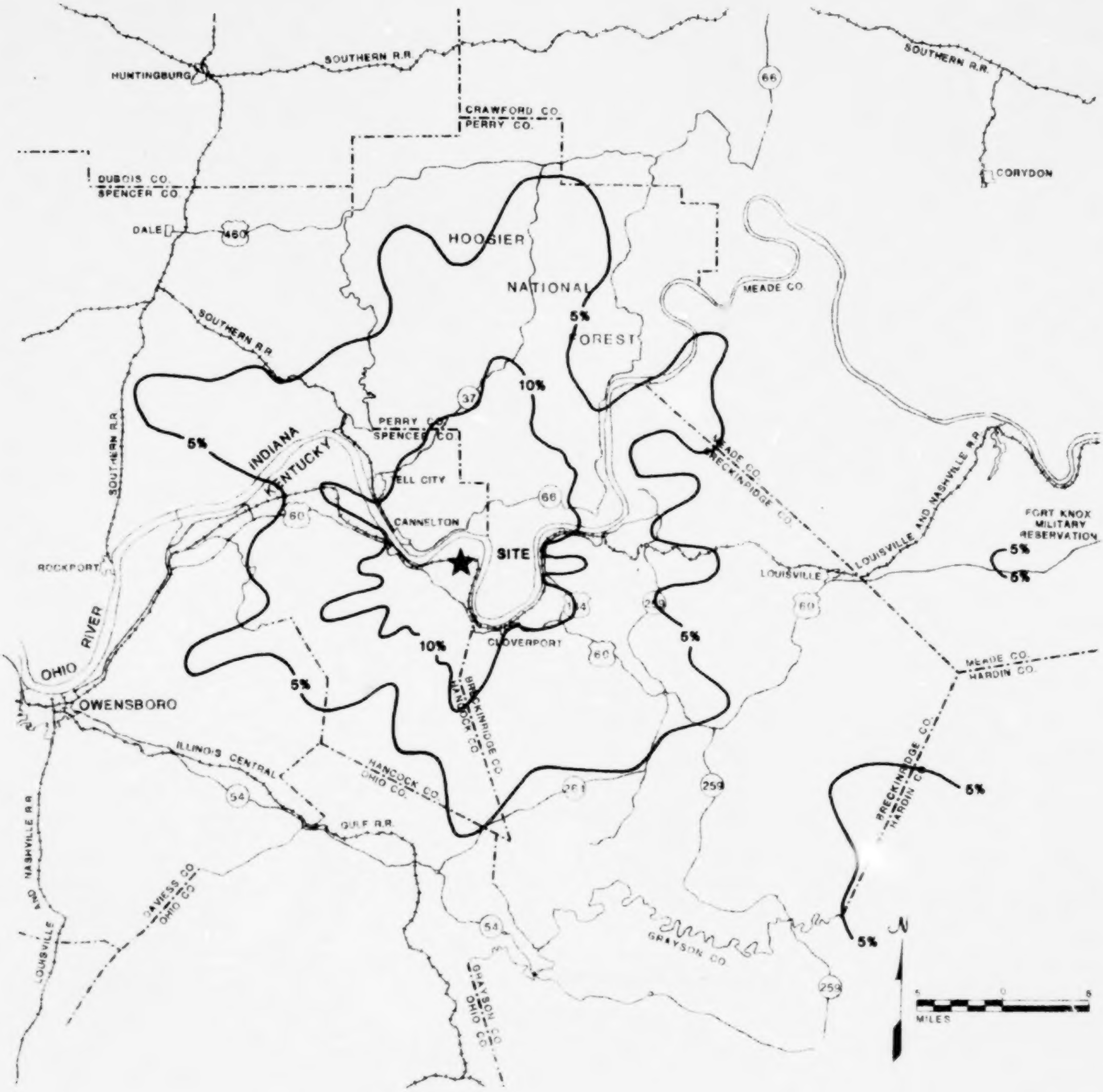
SOUTHERN R.R.
HUNTINGBURG
66
CRAWFORD CO.
PERRY CO.
DUBOIS CO.
SPENCER CO.
DALE
460
HOOSIER
NATIONAL
FOREST
CORYDON
SOUTHERN R.R.
MEADE CO.
5%
10%
SOUTHERN R.R.
SOUTHERN R.R.
INDIANA
KENTUCKY
PERRY CO.
SPENCER CO.
37
TELL CITY
CANNELTON
66
60
SITE
ROCKPORT
MEADE CO.
BRECKINRIDGE CO.
LOUISVILLE AND NASHVILLE R.R.
FORT KNOX
MILITARY
RESERVATION
LOUISVILLE
60
OHIO RIVER
OWENSBORO
CLOVERPORT
60
MEADE CO.
HARDIN CO.
BRECKINRIDGE CO.
HANCOCK CO.
ILLINOIS CENTRAL
HANCOCK CO.
OHIO CO.
54
GULF R.R.
261
259
BRECKINRIDGE CO.
HARDIN CO.
LOUISVILLE AND NASHVILLE R.R.
DAVIESS CO.
OHIO CO.
54
GRAYSON CO.
GRAYSON CO.
OHIO CO.
259
N
5
0
5
MILES

Figure 4.2-2. Percent of 3-Hour Class II Increment for SO_2 Consumed Offsite by Hancock Generating Station Units 1 and 2.

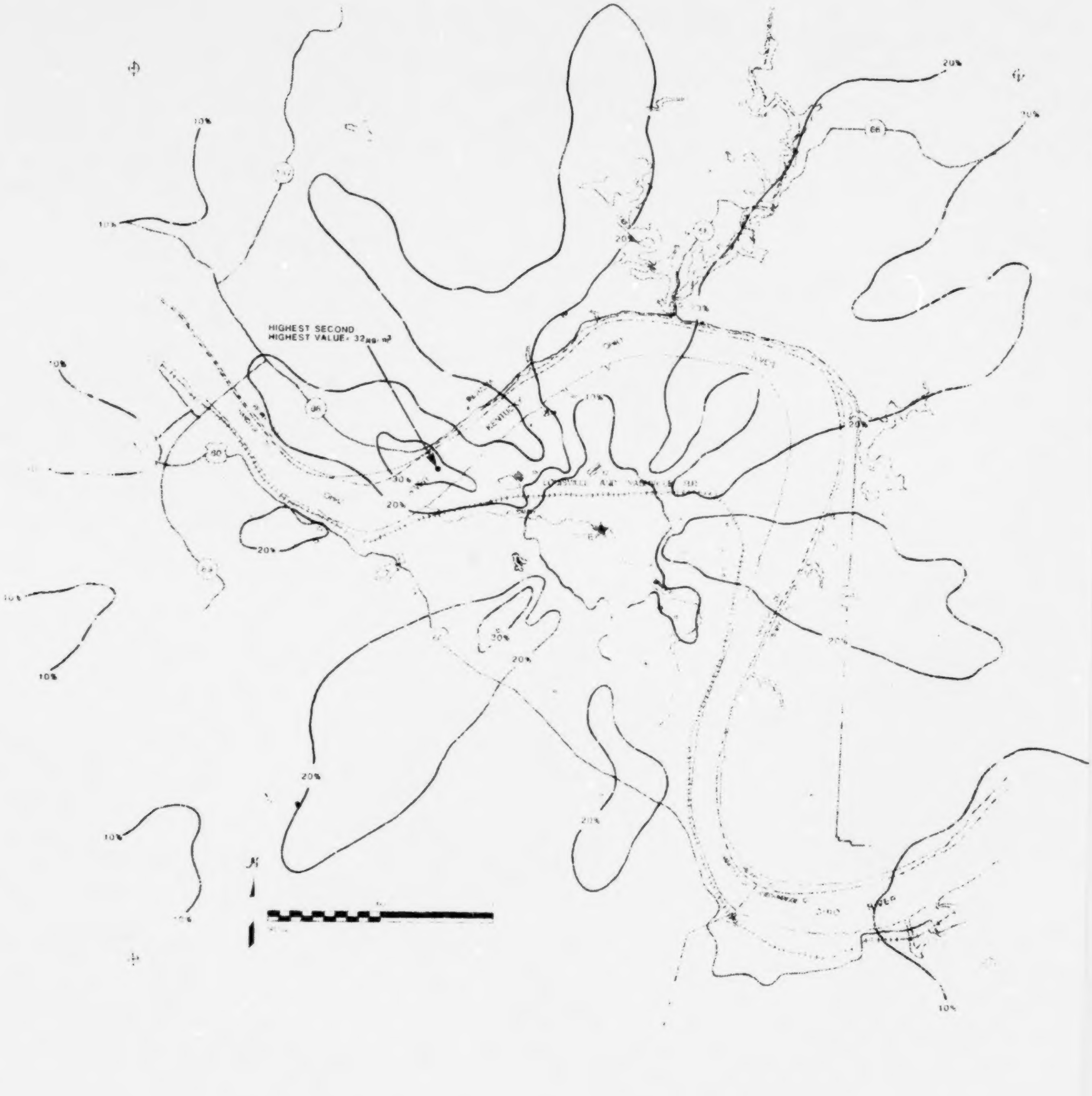
HIGHEST SECOND
HIGHEST VALUE- 32 µg/m³
10%
10%
10%
10%
10%
10%
10%
20%
20%
20%
20%
20%
20%
20%
20%
20%
20%
20%
30%
66
N

Figure 4.2-3 Percent of 24-Hour Class II Increment for SO_2 Consumed Onsite by Hancock Generating Station Units 1 and 2

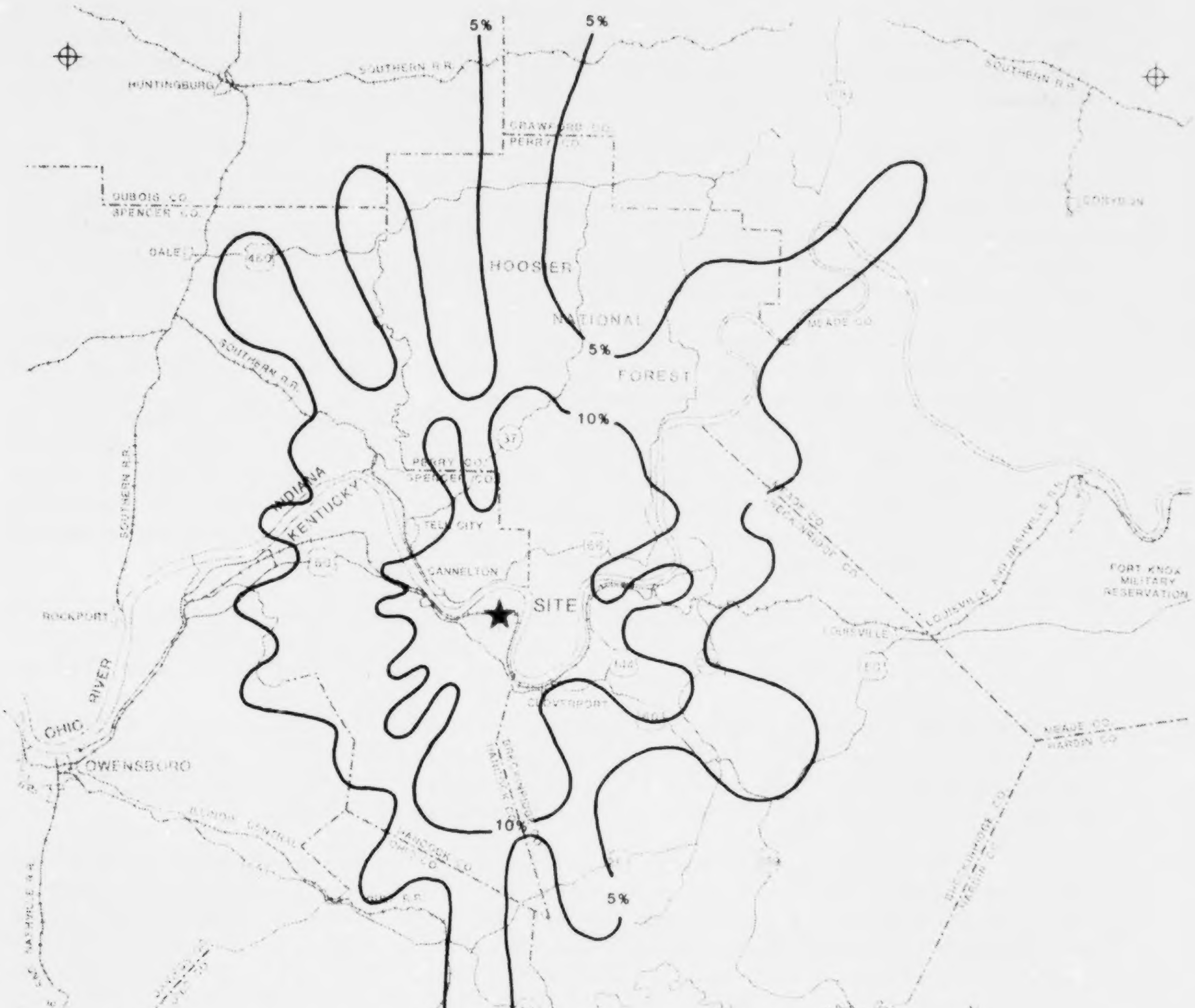
5%
5%
HUNTINGBURG
SOUTHERN R.R.
CRAWFORD CO.
PERRY CO.
DUBOIS CO.
SPENCER CO.
CORYDON
DALE
460
HOOSIER
NATIONAL
FOREST
MEADE CO.
5%
SOUTHERN R.R.
10%
37
PERRY CO.
SPENCER CO.
INDIANA
KENTUCKY
SOUTHERN R.R.
TELL CITY
66
CANNELTON
FORT KNOX
MILITARY
RESERVATION
ROCKPORT
SITE
LOUISVILLE & NASHVILLE R.R.
RIVER
CLOVERPORT
OHIO
MEADE CO.
HARDIN CO.
OWENSBORO
ILLINOIS CENTRAL
HANCOCK CO.
BRECKINRIDGE CO.
10%
5%
GRAYSON CO.
MILES
5%
5%

Figure 4.2-4. Percent of 24-Hour Class II Increment for SO_2 Consumed Offsite by Hancock Generating Station Units 1 and 2

Greatest short-term and long-term ground-level concentrations of particulates attributable to the Hancock plant will be on the Ohio River just southeast of the Hancock plant barge unloader. Maximum 24-hour TSP at this point is predicted to be 32 $\mu g/m^3$ and annual average TSP is estimated at 2 $\mu g/m^3$. These predictions are based on 50% (e.g., wet suppression of coal pile) and higher emissions control efficiencies (e.g., 90% for partial enclosure and baghouse at barge unloader) for various handling equipment and facilities.

Chimney and fugitive emissions from the power plant, although not exceeding regulatory standards, will degrade ambient air quality at either site. At the Hancock site, this degradation could produce economic as well as environmental effects. The effects of entry of coal particles into Willamette's bleached pulp product system depend upon particle size, as indicated by Willamette's description of their cleaning system specifications:

> Under control conditions, with feed consistency of 0.5% and temperature of 120 - 140°F, the cleaners are capable of 80% removal of wood shives, which have a specific gravity of 0.7 to 0.8 grams per cc. Under these control conditions in the laboratory the cleaners are 80 to 90% efficient at removing particles with a size greater than 0.025 mm. If in actual operation, the inlet consistency to the cleaners increases to 1%, the efficiencies drop to 40-45%. Due to operating conditions, we are forced to run the feed consistency to our cleaners at 0.95 to 1.0%, which lowers their efficiency.
>
> Pulp fiber has a specific gravity of 1.27 to 1.40 compared with 1.20 to 1.50 for bituminous coal, which makes it very difficult for the central cleaners to differentiate between coal and pulp fiber.

Based on these specifications, Willamette has assumed an 85% removal efficiency for coal dust settling on the wood chip pile. Willamette also has stated that daily economic loss from coal dust contamination could approach $187,000 (1981 dollars for each day of off-grade bleached pulp production).

To estimate impact of KU s operation on bleached pulp production, computer modeling was used to derive days of bleached pulp degradation from #1 to #2 prime and days of off-grade production. For pulp production, wood chips are removed in a bottom-to-top, pie-shaped section from one of two piles that together contain approximately 100,000 tons at capacity and are cycld approximately every 50 days. Thus, on any given day, wood chips entering the pulp process would contain coal dust that was deposited during the preceding 50 days.

Computer model runs based on two different methodologies (see Section 2.5) gave annual total coal dust deposition on the chip pile of 3,757 and 67,659 grams, respectively. Assuming that local meteorology used in the latter study probably is more reflective of potential conditions, results of that study are reported. These include an average daily deposition of 185.4 grams and a maximum 50-day running average deposition of 485 grams.

The impact of the coal dust would be determined by its effect on the bleached pulp mat, which is the product Willamette sells and will use later in the new fine paper plant. Willamette's test procedures count visible dirt on samples of mat at regular intervals. The amount of dirt is estimated by comparing observed particles with a size standard and summing the total area of all visible dirt. The test involves wetting the mat so that subsurface particles are counted. A total visible dirt area of 0 to 3 mm^2 per m^2 is within #1 prime standards. Number two prime has 3.1 to 6 mm^2 per m^2 dirt area, and greater than $6mm^2/m^2$ is off grade. This test does not evaluate the effect of subvisible particles, which, if present in sufficient numbers, may cause a gray tint that makes the mat unsuitable for fine white paper. Brightness degradation in the past has been associated with fire in the wood chip pile.

Coal dust and dirt count may be related by assuming that the average visible particle is 0.02 mm^2 in cross section (from Willamette's standard particle size chart) and 1% of emitted coal particles are in the visible range (from EPA's "Survey of Fugitive Dust from Coal Mines"). The area of pulp mat obscured by one gram of coal dust would be 6,963 mm^2. When considered relative to daily pulp production (2000 ft^2 per minute = 267,561 m^2 per day), this results in a visible dirt count (DC) of 0.026 mm^2 per m^2 on that day. To derive DC from coal dust (CD) that falls in the chip pile, 0.026 is reduced (R) by the percent of coal particles the cleaning process fails to remove (15%) and the percent visible emissions (1%) (R = 0.01 x 0.15). Average background dirt count (ADC) is considered, so that:

$$DC = (0.026 \times R \times CD) + ADC$$

Based on ADC of 1.94, the CD deposition required to achieve a DC of 3.1 is 29,744 grams. Since the maximum 50-day running average deposition predicted by the model was 485.5 grams, the model demonstrates no impact from the coal storage with respect to visible dirt count.

This equation does not account for possible brightness degradation from subvisible particles and, as mentioned, there is no quantitative standard for calculating loss of brightness. Based on emitted coal dust having a median particle size of 20 microns (from EPA document referenced above) and considering the cross-sectional area of a 20-micron particle ($3.1416 \times 10^{-10} m^2$), there will be 55.6 mm^2 of surface obscured by each gram of coal dust. A subvisible soil ratio (SSR) can be defined as the area occupied by subvisible particles relative to surface area of the pulp mat. The SSR is computed similar to dirt count, using a reducing factor (RSV) of 0.15 x 0.99. For each gram of subvisible coal dust in the pulp mat, the SSR is 0.000208 mm^2/m^2. SSR is derived from coal dust that falls in the chip pile by:

$$SSR = 0.000208 \times RSV \times CD$$

Unlike dirt count, SSR cannot be compared with a standard to determine days of off grade due to brightness loss.

The model used to compute coal deposition (Industrial Source Complex) is considered accurate to within a factor of two if emissions are steady state, terrain is flat to gently rolling, and several years of local meteorological data are available. In this case, an order of magnitude of uncertainty was considered appropriate for estimating impact based on lack of specific knowledge of numerous factors among these three conditions. Because of the unknown possibility of contamination from subvisible particles with 50% fugitive emissions control now proposed by KU, alternative methods of dust control or protection of the wood chip pile were suggested in Section 2.5.

4.2.2.2.2 Transmission System

Primary ambient air quality effects of the transmission system will result from fugitive dust emissions related to the construction of the transmission lines. Fugitive dust emission factors were determined using EPA's (1974) Compilation of Air Pollution Emission Factors (including Supplements 1-9). The emissions category most similar to construction activity was land tilling. The emissions factor utilized in quantification of fugitive dust emissions was:

$$E = \frac{1.4s}{\left(\frac{PE}{50}\right)^2}$$

where E = Emission factor, pounds per acre
s = Silt content of the surface soil, percent
PE = Thornthwaites precipitation-evaporation index

A silt content of 10% and a PE index of 115 were utilized. This resulted in an emissions factor of 2.65 pounds of particulates per acre.

The greatest ambient particulate effect will occur during the construction of the 250-foot-wide corridors, where each 175 feet of corridor construction would cover one acre. For dispersion modeling purposes the emission factor used was 4.995 pounds per 100 meters of corridor construction. As a worst case approximation, it was assumed that 400 meters of the corridor would be under clearing, scraping, etc., at any one time. The fugitive dust emissions were modeled as 4 point sources in a line 100 meters apart with a height of 2 meters, a radius of 5 meters, and an exit velocity of 5 meters per second.

A dust model that accommodates heavy particulate deposition by the tilted plume method was employed. Particulates were assumed to have a settling velocity of 5 centimeters per second. The results of the fugitive dust modeling are given in Table 4.2-2. As indicated, the maximum ambient particulate 24-hour concentration resulting from the transmission construction is 37 $\mu g/m^3$ at a distance approximately 200 meters downwind from the construction activity. This effect was considered to have a slight to moderate impact upon ambient particulate concentrations.

Table 4.2-2. Predicted Maximum Ambient Particulate Concentrations Resulting from New Transmission Construction, Hancock and Breckinridge Alternatives

Stability Class	Wind Speed (m/sec)	Maximum 24-Hour Concentration (mg/m^3)	Distance to Maximum Concentration (meters)
C	1.5	18	200
C	3.0	18	200
C	6.0	20	200
D	1.5	24	200
D	3.0	24	200
D	6.0	24	200
E	1.5	37	200
E	3.0	36	200
E	6.0	34	200
			200

These impacts are for the worst case condition resulting from the construction of the new transmission corridor, which will be associated with the 250-foot-wide corridor. The fugitive dust impact due to construction of the 100-foot-wide expansion of the Elizabethtown corridor was determined to have emissions of 100/250 or 40% of those along the new corridor. Thus, the effect of fugitive dust from the existing corridor expansion was determined to be 15 $\mu g/m^3$ under worst case conditions. This effect along the existing transmission corridor was considered to have a slight impact upon ambient particulate concentrations only during the construction period.

4.2.2.3 Breckinridge Site Alternative

4.2.2.3.1 Generating Station

The plant on the Breckinridge site, with a lower SO_2 removal efficiency, will consume 47% of the allowable 3-hour Class II SO_2 increment and 43% of the allowable 24-hour Class II SO_2 increment. The maximum 3-hour SO_2 increment consumption is expected to occur in a localized area in the eastern portion of the site (Figure 4.2-5). Offsite 3-hour SO_2 increment consumption will range from 25 to 35% of allowable in several adjacent areas, including the Ohio River (Figure 4.2-5), to 5 to 10% in outlying locations in Breckinridge and other surrounding counties (Figure 4.2-6). Isopleths of 24-hour SO_2 increment consumptions ranging from 20 to 30% of allowable will encompass relatively extensive adjacent offsite areas (Figure 4.2-7), and the isopleth of 5% of allowable will encompass a relatively large surrounding area that extends into several counties (Figure 4.2-8).

Estimated short-term impacts on air quality due to interaction between the plant on the Breckinridge site and the only new major point source of emissions within its zone of influence (Rockport Generating Station in Spencer County, Indiana, about 30 miles west of the site) are maximum 3-hour SO_2 concentration of 157 $\mu g/m^3$ and maximum 24-hour SO_2 value of 45 $\mu g/m^3$. These maximum concentrations are predicted to occur 0.7 mile and 1.0 mile west of the Breckinridge site, respectively. Multiplying the maximum 24-hour SO_2 concentration by the ratio of TSP to SO_2 emission rates results in a maximum 24-hour TSP concentration of 2 $\mu g/m^3$ 1.0 mile west of the Breckinridge site.

Predicted short-term interactions between the plant on the Breckinridge site and existing major point sources are greatest when the proposed plant and Coleman Station (13 miles west in Hancock County) are modeled simultaneously. The predicted maximum combined 3-hour SO_2 concentration is 372 $\mu g/m^3$ at a point 0.9 miles southeast of the Breckinridge site. The estimated maximum combined 24-hour SO_2 value is 57 $\mu g/m^3$ at the same point. Conversion of the combined maximum 24-hour SO_2 concentration by the ratio of TSP to SO_2 emission rates predicts a maximum combined 24-hour TSP level of 3 $\mu g/m^3$ at a point 0.9 miles SE of the Breckinridge site.

Long-term impacts predicted on regional air quality due to existing major point sources and the Breckinridge plant are maximum annual SO_2, TSP, and NO_2 concentrations of 2, 0.8, and 2 $\mu g/m^3$, respectively. These are predicted to occur about 2.4 miles northeast of the Breckinridge site.

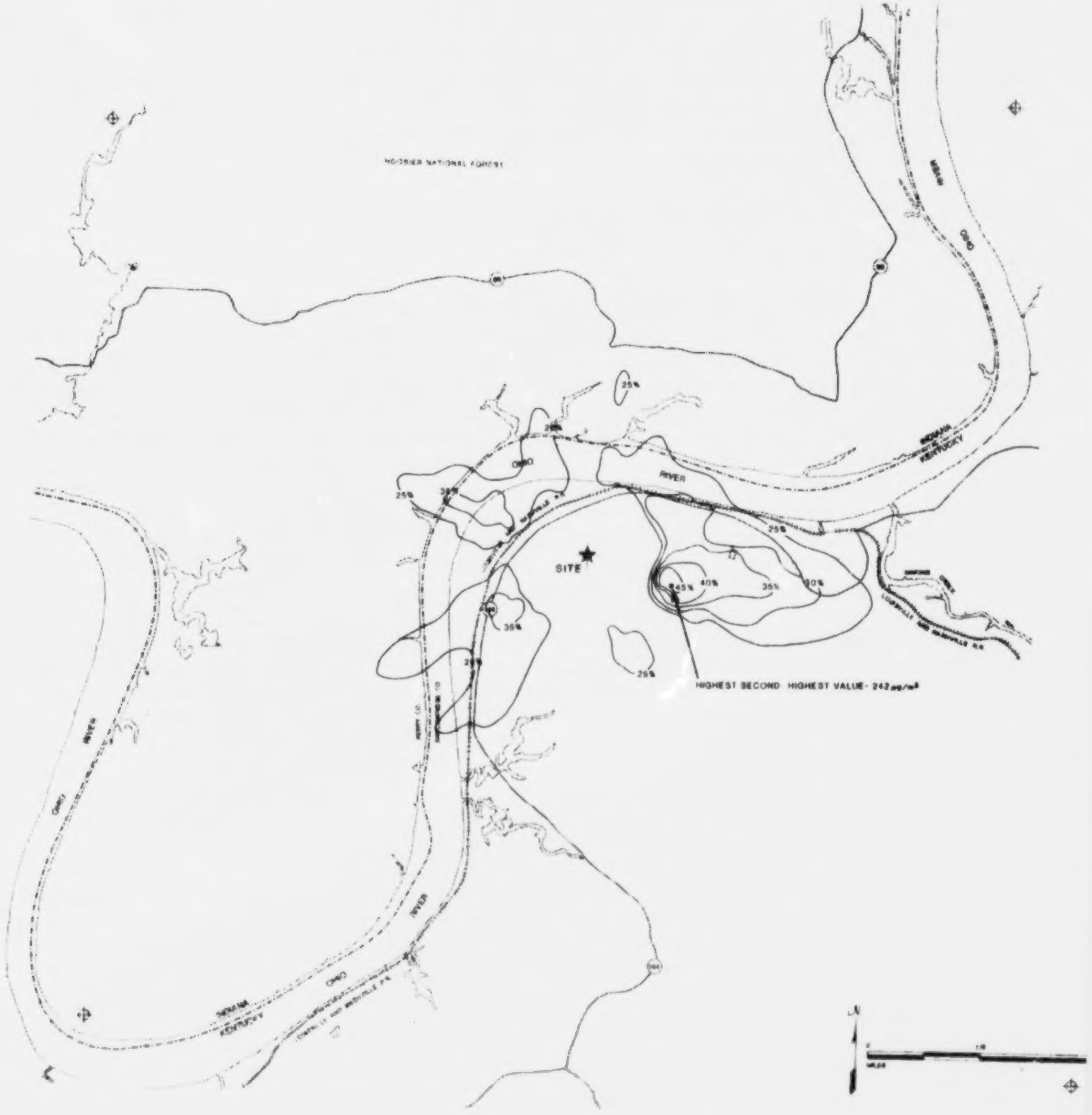
HOOSIER NATIONAL FOREST
INDIANA
KENTUCKY
OHIO
RIVER
25%
30%
35%
40%
45%
SITE
HIGHEST SECOND HIGHEST VALUE- 242 µg/m³
N

Figure 4.2-5. Percent of 3-Hour Class II Increment for SO_2 Consumed Onsite by the Proposed Power Plant on the Breckinridge Site

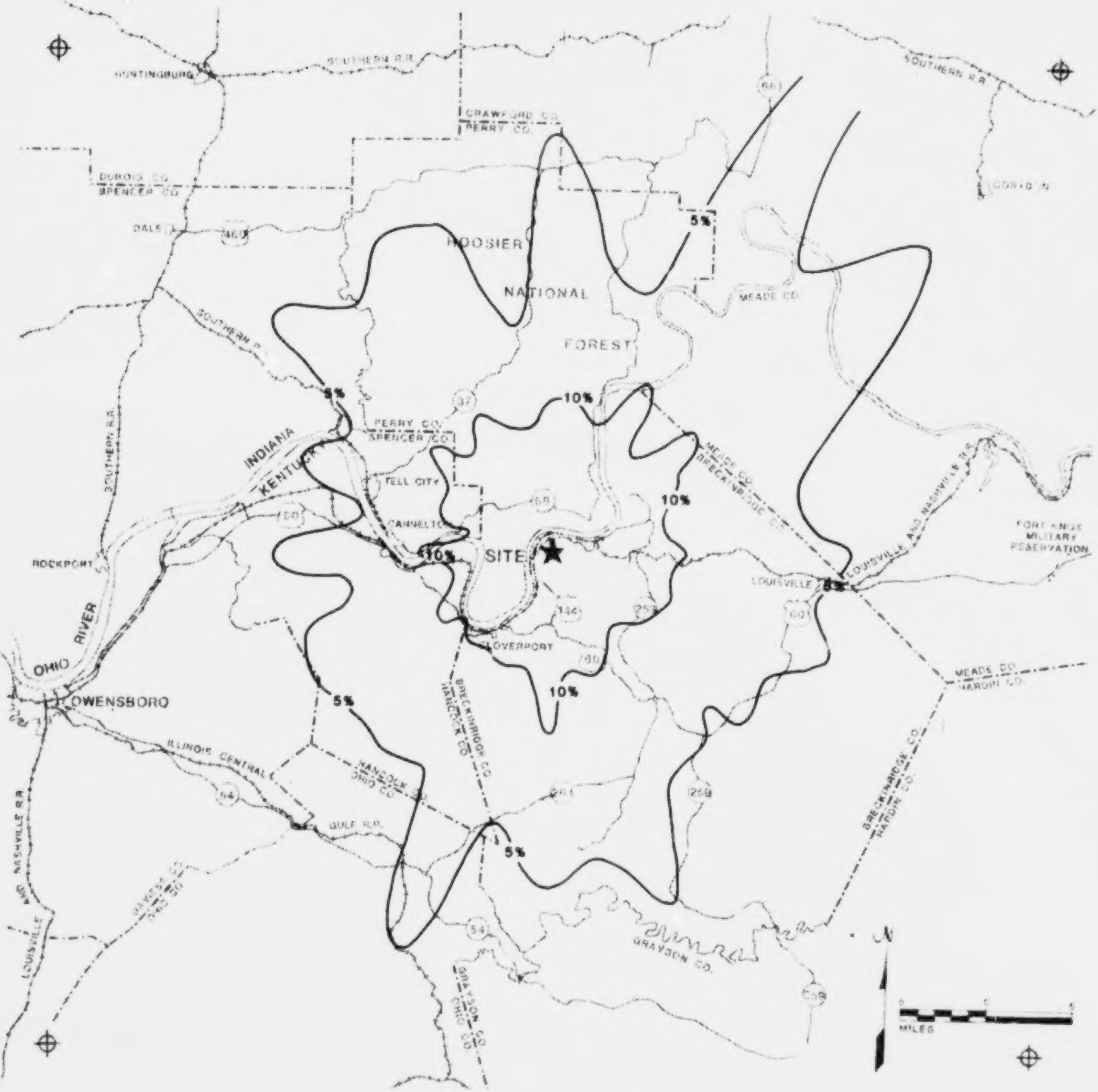
HUNTINGBURG
SOUTHERN R.R.
CRAWFORD CO.
PERRY CO.
DUBOIS CO.
SPENCER CO.
DALE
460
HOOSIER
NATIONAL
FOREST
5%
MEADE CO.
SOUTHERN R.R.
CORYDON
66
SOUTHERN R.R.
5%
37
10%
PERRY CO.
SPENCER CO.
INDIANA
KENTUCKY
TELL CITY
SOUTHERN R.R.
MEADE CO.
BRECKINRIDGE CO.
10%
68
CANNELTON
10%
SITE
166
ROCKPORT
FORT KNOX
MILITARY
RESERVATION
LOUISVILLE
5%
LOUISVILLE AND NASHVILLE R.R.
144
259
60
OHIO
RIVER
LOVERPORT
60
10%
MEADE CO.
HARDIN CO.
OWENSBORO
5%
BRECKINRIDGE CO.
HANCOCK CO.
ILLINOIS CENTRAL
HANCOCK CO.
OHIO CO.
54
261
259
BRECKINRIDGE CO.
HARDIN CO.
GULF R.R.
5%
LOUISVILLE AND NASHVILLE R.R.
DAVIESS CO.
OHIO CO.
54
GRAYSON CO.
259
N
0
5
MILES
GRAYSON CO.
OHIO CO.

Figure 4.2-6 Percent of 3-Hour Class II Increment for SO_2 Consumed Offsite by the Proposed Power Plant on the Breckenridge Site

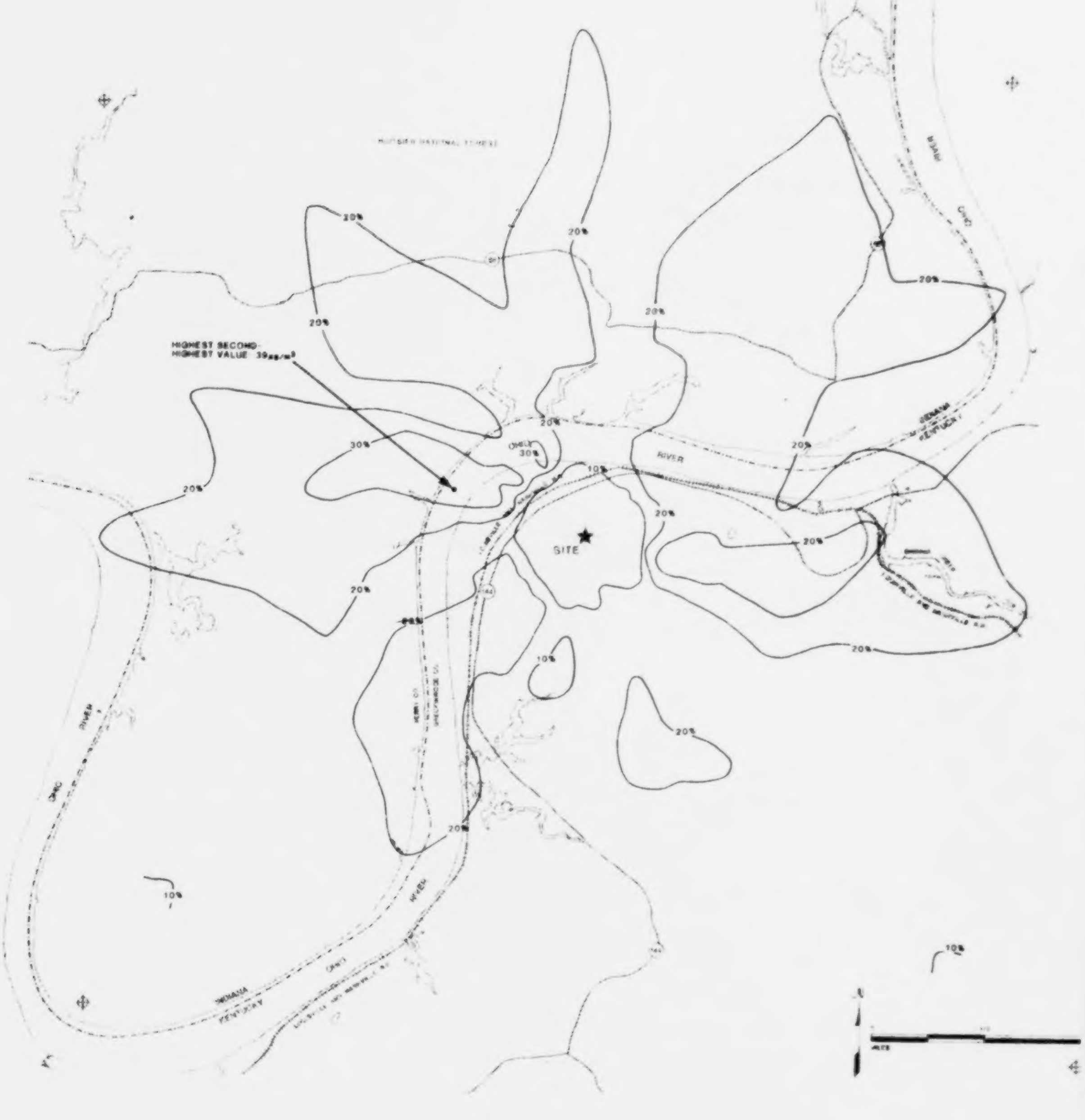
HOOSIER NATIONAL FOREST
HIGHEST SECOND-HIGHEST VALUE 39µg/m³
20%
20%
20%
20%
20%
30%
30%
20%
10%
20%
20%
20%
20%
20%
20%
20%
20%
10%
20%
20%
10%
10%
SITE
OHIO RIVER
RIVER
OHIO
INDIANA
KENTUCKY
OHIO
RIVER
INDIANA
KENTUCKY

Figure 4.2-7. Percent of 24-Hour Class II Increment for SO_2 Consumed Onsite by the Proposed Power Plant on the Breckinridge Site

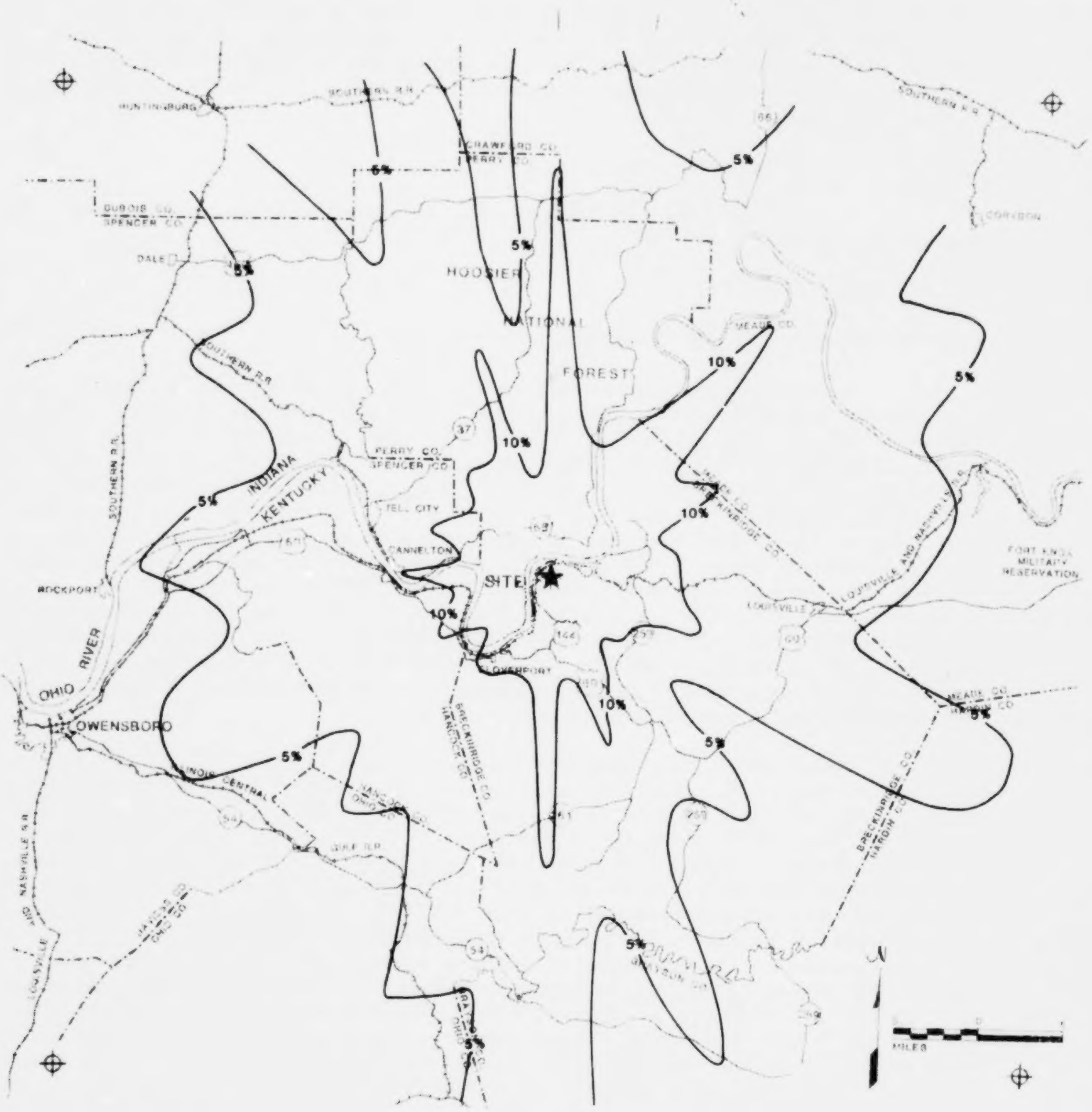
HUNTINGBURG
SOUTHERN R.R.
CRAWFORD CO.
PERRY CO.
DUBOIS CO.
SPENCER CO.
DALE
HOOSIER
NATIONAL
FOREST
MEADE CO.
CORYDON
SOUTHERN R.R.
PERRY CO.
SPENCER CO.
TELL CITY
CANNELTON
INDIANA
KENTUCKY
SOUTHERN R.R.
ROCKPORT
OHIO
RIVER
OWENSBORO
SITE
CLOVERPORT
BRECKINRIDGE CO.
HANCOCK CO.
LOUISVILLE
LOUISVILLE AND NASHVILLE R.R.
FORT KNOX MILITARY RESERVATION
MEADE CO.
HARDIN CO.
BRECKINRIDGE CO.
HARDIN CO.
ILLINOIS CENTRAL
HANCOCK CO.
OHIO CO.
LOUISVILLE AND NASHVILLE R.R.
OHIO CO.
GRAYSON CO.
MILES
5%
5%
5%
5%
5%
5%
5%
5%
5%
5%
5%
10%
10%
10%
10%
10%

Figure 4.2-8. Percent of 24-Hour Class II Increment for SO_2 Consumed Offsite by the Proposed Power Plant on the Breckinridge Site

Coal dust emissions and industry-limiting implications of air quality effects are not a public issue on the Breckinridge as on the Hancock site. The power plant as now proposed will not preclude development of the Ashland Oil synfuel plant adjacent to the site, but either could affect expansion of the other in the future. Coal dust emission from KU's coal system should not impact synfuel processes.

4.2.2.3.2 Transmission System

Transmission related impacts on air quality will be as described for the Hancock site.

4.2.3. Noise

4.2.3.1 General Effects on Ambient Noise Levels

During construction phases of the project, ambient noise levels will be affected by equipment operation and increased traffic. Highway traffic increases due to the project will lighten somewhat during operation of the plant, although truck traffic associated with the plant will remain substantially greater than presently, as will barge traffic. There also will be continuous, long-term noise effects due to boiler and cooling tower operations. Operation of the 345-kV transmission system could have slight noise effects of a buzzing nature directly under the lines, especially during inclement weather. Neither the Breckinridge nor Hancock site and transmission facilities are in noise-sensitive locations. In areas of public access, outside the plant boundaries, station-related noise levels are expected to be within acceptable ranges. Most effects on ambient noise levels and noise perception will occur locally at or near the project locations, with project-related noise in other locations generally masked by existing sources.

Among other noise control procedures (see Subsection 1.3.2.7.7), the Applicant proposes to abate noise from the generating station by equipping forced-draft (FD) and primary air fans with inlet silencers and the induced-draft (ID) fans with discharge silencers. The FD and ID fans are among the major power plant sources of environmental noise, along with safety valves, coal handling equipment, cooling towers, PA systems, boiler or reactor feed pumps, and station transformers (Edison Electric Institute 1978). The sound power levels of various equipment in a 600-MW coal-fired power plant, as well as the power levels of more familiar noise sources, are shown in Table 4.2-3. The actual sound, or noise, levels associated with the power plant equipment will depend on position of the receptor, directivity effects of the sound source, and other variables. Sound levels are more meaningful for considering apparent loudness and are used for comparison with standards and guidelines. The sound level of cooling towers proposed for the plant, for example, is 71 dB(A) at the source (Table 4.2-4). This noise level is considered loud and is equivalent to a freight train at 100 feet or average street noise (HUD 1971; see Table 3.2-17).

4.2.3.2 Hancock Site Alternative

The effects of operation of the power plant on ambient noise levels off the Hancock site were determined using a modification of the American Gas Association (1977) computer model AGASUM. The model used allows prediction of

Table 4.2-3. Rank Order of A-Weighted Sound Power Level of 600-MW Power Plant Untreated Sound Sources and Familiar Sound Sources

Sound Source	Sound Power Level [dB(A)]
Turbo-jet engine, 7000-lb thrust	170
High-pressure vents (safety valves)	147
4-propeller airliner	145
75-piece orchestra	130
Forced-draft fan inlet	125
Induced fan discharge	120
Precipitator rappers	120
Piano	120
Cooling tower	118
Boiler feed pump	117
Coal-yard dozer	116
Public address system	113
Blaring radio	110
River water makeup pump	106
Shouting voice	90
Conversational voice	70
Soft voice	30

Source: Peterson and Gross, Handbook of Noise Measurement (1974).
Edison Electric Institute, Electric Power Plant Environmental Noise Guide, Vol. 1 (1978).

noise level at multiple points due to a complex array of noise sources. Topography, vegetation, other barriers, and control are not factored in the analysis. The noisiest equipment modeled was the electrostatic precipitators, although, depending upon design, the safety valves venting steam to the atmosphere may be noisier than the precipitators. However, sound emisisons from high-pressure vents generally are short-term and are not considered continuous sound sources (Edison Electric Institute 1978). Safety valves, for example, may operate for a period of 10 seconds to 5 minutes whenever a valve is utilized to release pressure.

The maximum predicted continuous effect from the plant operation is 55 dB(A) (Table 4.2-4). The area that will experience the maximum effect is north of the Unit 2 cooling tower (Figure 4.2-9) where highway 1406 and the Louisville and Nashville R.R. switchyard are located. Although no noise measurements were made at the Hancock site, assumed ambient noise levels near the switchyard and Willamette Industries plant currently are between 50 and 60 dB(A) at various averaging times (see Subsection 3.2.3). A continuous noise of 55 dB(A) from the plant would represent an L_{dn} Outdoors of 61 dB(A), which is somewhat higher than the assumed existing L_{dn} Outdoors of 59 dB(A). Both L_{dn} levels exceed the guideline of 55 dB(A), which is identified as outdoor level in residential areas compatible with the protection of public health and welfare (EPA 1974). Both levels are below the guideline of $L_{eq(24)}$ = 70 dB(A) for protection against hearing loss. A noise level of 70 dB(A) and higher could be

Table 4.2-4. Kentucky Utilities Hancock Site Noise Analysis Power Plant Total Noise Contribution

SOURCE DATA

Source	Coordinates X (feet)	Coordinates Y (feet)	Radius (feet)	Source Sound Levels [dB(A)]
Precipitator	2200.0	500.0	1.0	114.
Turbine-Generator	2650.0	400.0	1.0	112.
Boiler	2600.0	400.0	1.0	85.
Turbine-Condenser	2680.0	400.0	1.0	114.
Electric Motor	2600.0	300.0	1.0	104.
Feed Pumps	2640.0	360.0	1.0	104.
Deaerator	2620.0	380.0	1.0	105.
Aux Boiler	2600.0	200.0	1.0	99.
P A System	3000.0	500.0	1.0	108.
Cooling Towers	3400.0	1600.0	75.0	71.
Coal Crusher	5000.0	-950.0	1.0	118.
Conveyors	5000.0	-990.0	1.0	116.
Coal Equipment	4800.0	-930.0	1.0	113.
Stacker-Reclaimer	4600.0	-950.0	1.0	106.
Coal Mills	2600.0	390.0	1.0	107.

PREDICTED SOUND LEVEL

Receptor	Coordinates X (feet)	Coordinates Y (feet)	Ambient Noise Level at Receptor* [dB(A)]
No. 1	0.0	1000.0	53.
No. 2	500.0	1500.0	53.
No. 3	1000.0	2000.0	54.
No. 4	1500.0	2500.0	54.
No. 5	2000.0	2500.0	54.
No. 6	2500.0	2500.0	55.
No. 7	3000.0	2500.0	55.
No. 8	3500.0	2500.0	55.
No. 9	4000.0	2500.0	55.
No. 10	4500.0	2500.0	54.
No. 11	-2000.0	0.0	48.
No. 12	-2000.0	1000.0	48.
No. 13	-1000.0	1000.0	50.
No. 14	-2000.0	2000.0	48.
No. 15	-1000.0	2000.0	50.
No. 16	0.0	2000.0	52.
No. 17	-2000.0	3000.0	47.
No. 18	-1000.0	3000.0	49.
No. 19	0.0	3000.0	50.
No. 20	1000.0	3000.0	52.
No. 21	2000.0	3000.0	53.
No. 22	3000.0	3000.0	53.
No. 23	4000.0	3000.0	53.
No. 24	5000.0	3000.0	52.
No. 25	6000.0	3000.0	51.
No. 26	-2000.0	4000.0	47.
No. 27	-1000.0	4000.0	48.
No. 28	0.0	4000.0	49.
No. 29	1000.0	4000.0	50.
No. 30	2000.0	4000.0	51.
No. 31	3000.0	4000.0	51.
No. 32	4000.0	4000.0	51.
No. 33	5000.0	4000.0	50.
No. 34	6000.0	4000.0	50.
No. 35	-2000.0	5000.0	46.
No. 36	-1000.0	5000.0	47.
No. 37	0.0	5000.0	47.
No. 38	1000.0	5000.0	48.
No. 39	2000.0	5000.0	49.
No. 40	3000.0	5000.0	49.
No. 41	4000.0	5000.0	49.
No. 42	5000.0	5000.0	49.
No. 43	6000.0	5000.0	48.

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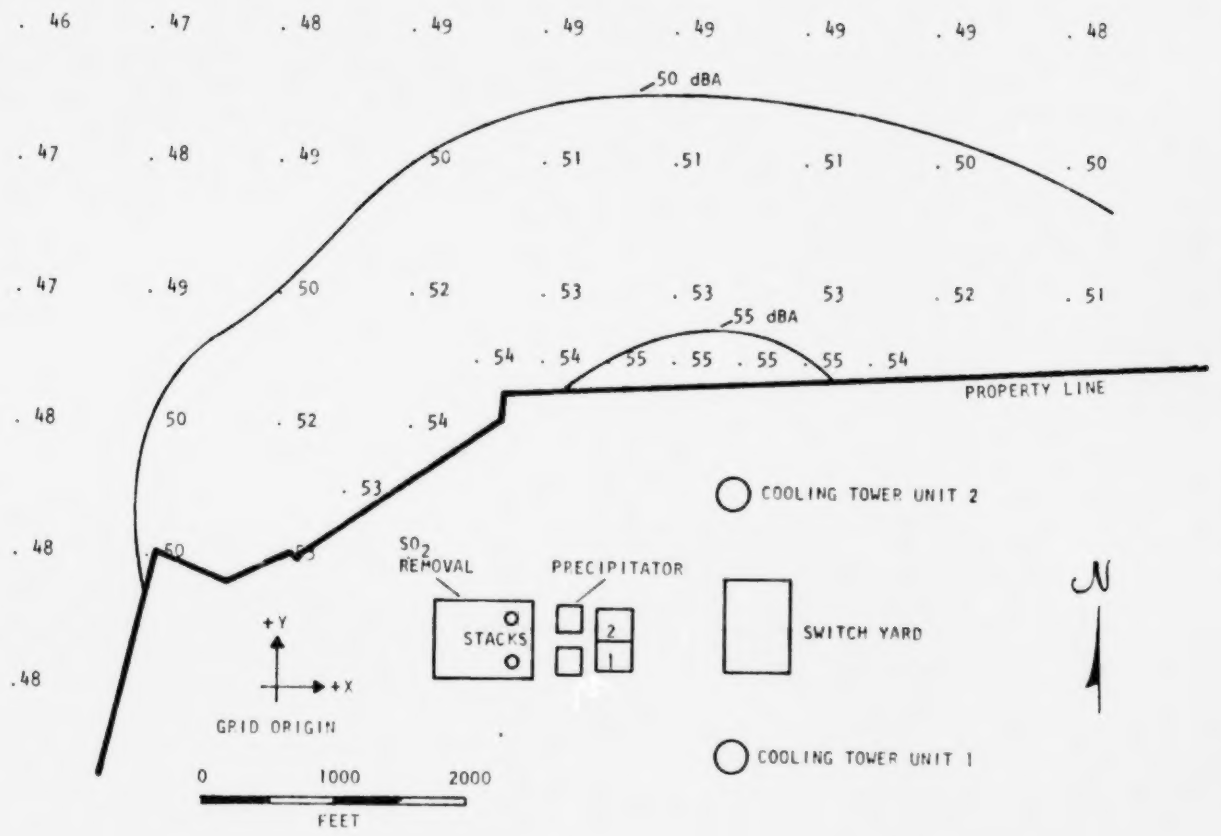
*Predicted by American Gas Association computer model AGASUM.


. 46 . 47 . 48 . 49 . 49 . 49 . 49 . 49 . 48
50 dBA
. 47 . 48 . 49 50 . 51 .51 . 51 . 50 . 50
. 47 . 49 50 . 52 . 53 . 53 53 . 52 . 51
55 dBA
. 54 . 54 55 . 55 . 55 55 . 54
. 48 50 . 52 . 54
. 53
. 48 50 53
.48
PROPERTY LINE
COOLING TOWER UNIT 2
SO2 REMOVAL
STACKS
PRECIPITATOR
2
1
SWITCH YARD
N
+Y
+X
GRID ORIGIN
COOLING TOWER UNIT 1
0
1000
2000
FEET

SOURCE: Texas Instruments (1980), using AGASUM model

Figure 4.2-9. Projected Operational Ambient Noise Levels, Hancock Site

associated with safety valve operation on occasion, but there would be no impact on human health.

An occupied house on highway 1406 northwest of the plant facilities will be subjected to highest noise levels from the plant because virtually no barriers exist between the house and the plant. A few dwellings northeast of the railway yard are within locations modeled to experience L_{dn} Outdoors of about 55 dB(A) but vegetation between the plant and the dwellings should attenuate noise from the plant.

4.2.3.3 Breckinridge Site Alternative

The results of the AGASUM noise model for the power plant on the Breckinridge site predict a maximum offsite noise level due to plant operation of 56 dB(A) (Table 4.2-5). The maximum level is expected to occur south of the cooling towers (Figure 4.2-10). Noise levels assumed representative of background currently existing at the Breckinridge site are L_d= 51 dB(A), L_n = 35 dB(A), and L_{dn} outdoors = 50 $_g$ dB(A). These levels are associated with motor, railway, and barge traffic. They are lower than currently existing at the Hancock site. Further, there are no continuous major noise sources at the Breckinridge site comparable with industrial noises existing at the Hancock site. Thus, the impact on background noise at the Breckinridge site will be greater than on the Hancock site. However, the impact on nearby residents is expected to be similar, with only one occupied dwelling within range of the expected maximum L_{dn} outdoors. Ridges separate the site area from a relatively close residential area (Stephensport, Ky.).

Table 4.2-5. Kentucky Utilities Breckinridge Site Noise Analysis Power Plant Total Noise Contribution

SOURCE DATA

Source	Coordinates X (feet)	Coordinates Y (feet)	Radius (feet)	Source Sound Levels [dB(A)]
Precipitator	4000.0	6000.0	1.0	114.
Turbine-Generator	4250.0	5600.0	1.0	112.
Boiler	4200.0	5800.0	1.0	85.
Turbine Condenser	4500.0	5500.0	1.0	114.
Electric Motor	4550.0	5500.0	1.0	104.
Feed Pumps	4250.0	5800.0	1.0	104.
Deaerator	4250.0	5850.0	1.0	105.
Aux Boiler	4500.0	6000.0	1.0	99.
P A System	4000.0	5500.0	1.0	108.
Cooling Towers	2300.0	4500.0	75.0	71.
Coal Crusher	4000.0	7500.0	1.0	118.
Conveyors	4000.0	8000.0	1.0	116.
Coal Equipment	4100.0	8000.0	1.0	113.
Stacker-Reclaimer	4500.0	7800.0	1.0	106.
Coal Mills	4250.0	5750.0	1.0	107.

PREDICTED SOUND LEVEL

Receptor	Coordinates X (feet)	Coordinates Y (feet)	Ambient Noise Level at Receptor* [dB(A)]
No. 1	0.0	4000.0	50.
No. 2	500.0	3750.0	50.
No. 3	1000.0	3500.0	51.
No. 4	2000.0	4000.0	56.
No. 5	3000.0	4000.0	56.
No. 6	3000.0	3500.0	54.
No. 7	4000.0	3500.0	54.
No. 8	0.0	3000.0	49.
No. 9	1000.0	3000.0	50.
No. 10	2000.0	3000.0	52.
No. 11	3000.0	3000.0	52.
No. 12	4000.0	3000.0	53.
No. 13	5000.0	3000.0	52.
No. 14	6000.0	3000.0	51.
No. 15	0.0	2000.0	48.
No. 16	1000.0	2000.0	49.
No. 17	2000.0	2000.0	50.
No. 18	3000.0	2000.0	50.
No. 19	4000.0	2000.0	50.
No. 20	5000.0	2000.0	50.
No. 21	6000.0	2000.0	50.
No. 22	0.0	1000.0	47.
No. 23	1000.0	1000.0	47.
No. 24	2000.0	1000.0	48.
No. 25	3000.0	1000.0	48.
No. 26	4000.0	1000.0	49.
No. 27	5000.0	1000.0	48.
No. 28	6000.0	1000.0	48.
No. 29	7000.0	1000.0	47.
No. 30	0.0	0.0	46.
No. 31	1000.0	0.0	46.
No. 32	2000.0	0.0	47.
No. 33	3000.0	0.0	47.
No. 34	4000.0	0.0	47.
No. 35	5000.0	0.0	47.
No. 36	6000.0	0.0	47.
No. 37	7000.0	0.0	46.

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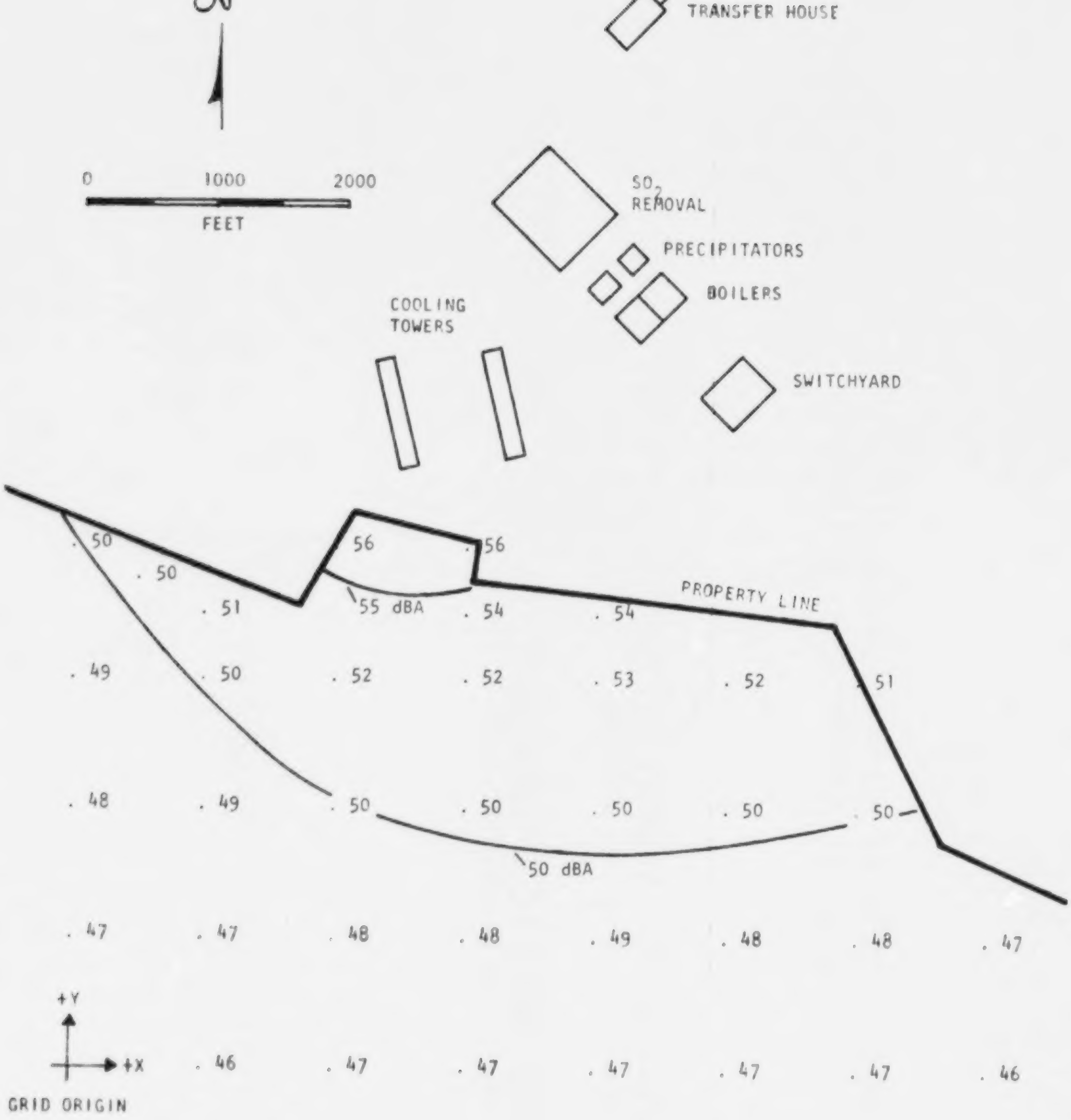
*Predicted by American Gas Association computer model AGASUM.


N
0
1000
2000
FEET
TRANSFER HOUSE
SO$_2$ REMOVAL
PRECIPITATORS
BOILERS
COOLING TOWERS
SWITCHYARD
50
56
56
50
51
55 dBA
54
54
PROPERTY LINE
49
50
52
52
53
52
51
48
49
50
50
50
50
50
50 dBA
47
47
48
48
49
48
48
47
+Y
+X
46
47
47
47
47
47
46
GRID ORIGIN

SOURCE: Texas Instruments (1980), using AGASUM model

Figure 4.2-10. Projected Operational Ambient Noise Levels, Breckinridge Site

4.3 LAND

Terrestrial components of the environment that will be irreversibly altered by the project include topographic features and soils. These alterations will impact distributions of prime farmland and existing floral and faunal associations. No threatened and endangered species apparently will be directly affected by the project, but species believed to be in danger of extirpation in Kentucky will be.

4.3.1 Geology

The geologic conditions of the site that is developed will be affected by alteration of topographic features and mechanical strengthening of the sites recent alluvial deposits. Similar effects will occur where access roads and transmission towers will be constructed. These effects will be confined to the site and localized in areas along the transmission corridor. They will be the same regardless of which site is developed, although secondary impacts (e.g., loss of existing soil resource) will differ in magnitude, as discussed in following sections.

Land preparation prior to and during construction of the project will include structural excavations and fills to attain the required grade. These excavations and fills will alter the surface loadings on the subsurface geologic formations. Geologically, the effects will be negligible.

Grading and compaction of surface areas for facilities development will occur on 700 to 800 acres of the site, primarily in lower elevations and low-relief areas. These activities will mechanically strengthen the alluvial deposits and will be beneficial for long-term industrial use of the site. The foundations for the generating station will include installation of pilings that also will increase the mechanical stability of the surface geologic formation.

During operation of the plant, most of the remaining land in the site boundaries - 1500 to 1600 acres in higher elevations and areas of greater relief - will be used for solid waste disposal. Deposition of these materials will require land clearing, but grading and compaction will be limited primarily to roadways. Filling of ravines, benching, and required grading will remove topographic variations. Deposition of the cementitious waste, approximatley 43.8 million tons, will increase the surface loadings on subsurface geologic formations, with minimal geologic impacts.

4.3.2 Soils

The principal impact on soils from the project will be mixing, compaction, and erosion. Additionally, there is potential for chemical alteration of the soil from seepage, leaching, and deposition of atmospheric emissions. Soils disturbance of this extent is essentially irreversible and results in permanent loss of prime farmland and deep, fertile, well developed sites necessary for certain existing plant communities.

4.3.2.1 General Effects on Soils Characteristics

The existing soil resource will be essentially lost in all portions of the site where major construction occurs. Once the profile is destroyed and upper layers removed, the soil cannot be returned to its preconstruction condition. During grading, topsoil and subsoil are mixed, and valuable organic matter in the topsoil is lost. The biological productivity of the new surface is reduced, texture is altered, and soil moisture is generally lowered. If done, removal and stockpiling of topsoil will save part of the soil resource for landscaping around major facilities and for aiding revegetation of landfill areas. However, certain physical, chemical, and biological changes occur during storage that diminish soil productivity so that loss of topsoil resource is reduced but not completely prevented. Also, the natural profile is disrupted even when topsoil is saved. Alteration of the profile prevents the reestablishment of existing natural vegetation communities, especially certain forest associations (see following section).

In addition to topsoil loss and profile disturbance, compaction and erosion will occur as areas are cleared and facilities are constructed. Heavy equipment will cause compaction on access and haul roads as well as in the main construction area. Surface erosion during light rainfall will occur on newly graded ground cleared of vegetation, even on 2% slopes (Lynch 1971). Limiting the amount of land cleared during site development (as described in Subsections 1.3.2.1 and 1.3.2.7.4) and landfill operations (Subsection 1.3.2.8.5) and prompt successful revegetation will reduce soil erosion. A temporary retention basin with a filter system will be associated with each landfill increment to prevent offsite siltation. However, erosion and onsite siltation will occur, with the extent depending on rainfall and effectiveness of revegetation.

Many of the soils on which facilities are to be constructed are prime farmland soils. Construction of the generating station will permanently commit this land to other uses besides agriculture. Most of the area to be occupied by landfills is presently vegetated with deciduous forests. Clearing and filling slopes in these areas with up to 45 feet of solid waste will alter the soil strata so extensively that it will take hundreds of years for soils to be suitable for some of the existing forest communities to return; some communities will never reestablish because of topographic changes.

Clay lining of Ponds A, B, and C will minimize seepage, so that potential soils impacts from operation of the generating station involve seepage and runoff of materials from coal and limestone storage areas and solid waste landfill areas. Coal storage areas that are located on unsealed (with clay or synthetic material) relatively pervious foundations are sources of trace elements and ions (e.g., sulfate) during long periods of precipitation (FWS 1978). There is even higher risk of leaching and erosion from similarly located limestone storage piles during extended rainfall. Runoff from limestone storage areas can add excess calcium to the soil, increasing the pH and tieing up soil nutrients. Regions of high humidity, like the project area, tend to have more acidic soils, which have low buffering capacity and are more sensitive to alkaline leachate (FWS 1978). Unlike sludges, the solid waste product to be deposited in the landfill areas will be dry, reducing the possibility of seepage, although leaching by rainfall may occur (FWS 1978). Infiltration of soils and groundwater by the leachate is more likely in areas of high rainfall, while infiltration from seepage is more probable when waste is deposited on permeable soils with high water tables. Runoff prior to stabilization of landfill areas could also contaminate adjacent soils with trace elements from the ash and sludge product, although the temporary retention basins should be in place until a landfill increment is stabilized.

Trace element deposition from air emissions may become adverse if soils already contain concentrations of these elements that approach threshold levels for toxicity. Although the probability of such levels is unknown, acid conditions, including natural soil acidity and acids in precipitation can cause plants to take up and hold greater amounts of potentially toxic substances (EPA 1980). Additionally, availability of certain essential elements (e.g., nitrogen, calcium, magnesium, phosphorous, potassium, molybdenum) is limited by increased acidity of soils (Buckman and Brady 1969). Acid precipitation has a greater impact on soils that have low buffering capacity and high rainfall. As with leaching and seepage, contamination of the soil ultimately affects vegetation and wildlife as well.

4.3.2.2 Hancock Site Alternative

Development of the Hancock site will destroy about 1050 acres of prime farmland soils. The remaining soils (1300 acres), which currently support pasture and woodlands, will be altered to the extent of not being able to sustain current vegetation.

4.3.2.2.1 Generating Station

Construction. The soil profile will be altered on all portions of the site except undisturbed buffer zones. Loss of natural contouring in the major construction area and in the landfill areas will alter surface water flow in direction and quantity, eroding all cleared areas until vegetation is reestablished. Surface runoff probably will increase four or fivefold and onsite erosion will increase similarly (Lynch 1971) to alter the soils. Most of the soils on the Hancock site are silt loams, which are more easily eroded than clay soils. Topsoil will be lost either from erosion or grading, and the productive potential of the soil will be reduced. The steepness of slopes in the landfill areas around Jeffry Cliff and Shafer Hill will necessitate frequent benching.

Operation. The potential for leaching and seepage of trace elements from coal and limestone piles, retention basins, and stabilized waste disposal areas on the Hancock site is related to soil properties, including depth to water table. Descriptions of the soil properties at the proposed locations of these structures and landfills on the Hancock site (see Figure 1.3-2) are given in Table 4.3-1. Most of the soils are silt loams, many have seasonal water tables less than 6 feet from the surface, and all have moderate permeability in the range of 0.6 to 2 inches per hour.

Table 4.3-2 describes the potential for adverse effects to soils, the food chain, and groundwater from unlined ash and sludge disposal sites (FWS 1978). Disposal of dry waste should result in a low to moderate probability of contamination. There will be virtually no seepage of waste liquors from the dry wastes, so that leaching by rainfall will be the primary mode of materials movement. Although no leaching data are available on the precise waste product proposal by KU, soils characteristics of the disposal sites indicate a high probability of soil and groundwater infiltration from whatever leaching may occur. Waste will be deposited directly on the soil, which is loamy in nature, in an area where average annual precipitation is 44.4 inches (USDA Soil Conservation Service 1974). Although the soils are only moderately permeable, rainfall is high, and the seasonal high water table is shallow in many of the

Table 4.3-1. Estimated Soils Properties at Proposed Locations for Holding Ponds, Coal and Limestone Storage Piles and Retention Basin, and Solid Waste Landfill Areas, Hancock Site

Facility	Soil Series	Texture	Permeability	Depth to Seasonal High Water Table (feet)	Depth to Bedrock (feet)
Holding Ponds					
Ponds A and B	Belknap	Silt loam	Moderate*	0.5 to 1.5	>7
	Weinbach	Silt loam	Moderate	0.5 to 1.5	>50
Pond C	Collins	Silt loam	Moderate	1.5 to 3	>10
	Elk	Silt loam	Moderate	>6	>50
	Otwell	Silt loam	Moderate	1.5 to 2.5	>50
Coal and Limestone Retention Basin	Belknap	Silt loam	Moderate	1.5 to 2.5	>7
	Grenada	Silt loam	Moderate	1.5 to 2.5	>6
Coal Storage Pile	Grenada	Silt loam	Moderate	1.5 to 2.5	>6
	Loring	Silt loam	Moderate	2.0 to 6.0	6.0 to 12.0
Limestone Storage Pile	Calloway	Silt loam	Moderate	0.5 to 1.5	>4
	Loring	Silt loam	Moderate	2.0 to 6.0	6.0 to 12.0
Solid Waste Landfills					
Area 1	Belknap	Silt loam	Moderate	0.5 to 1.5	>7
	Frondorf	Silt loam	Moderate	>6	1.5 to 3.5
	Otwell	Silt loam	Moderate	1.5 to 2.5	>50
	Weinbach	Silt loam	Moderate	0.5 to 1.5	>50
	Wellston	Heavy silt loam	Moderate	>6	3.0 to 6.0
	Zanesville	Silt loam	Moderate	2.0 to 2.5	4.0 to 6.0
Area 2	Belknap	Silt loam	Moderate	0.5 to 1.5	>7
	Calloway	Silt loam	Moderate	0.5 to 1.5	>4
	Grenada	Silt loam	Moderate	1.5 to 2.5	>6
	Henshaw	Silt loam	Moderate	1.0 to 2.0	>20
	Loring	Silt loam	Moderate	2.0 to 6.0	6.0 to 12.0
	Newark	Silt loam	Moderate	0.5 to 1.5	>20
	Sciotoville	Loam	Moderate	1.5 to 2.5	>50
	Wellston	Heavy silt loam	Moderate	>6	3.0 to 6.0
Area 3	Belknap	Silt loam	Moderate	0.5 to 1.5	>7
	Frondorf	Silt loam	Moderate	>6	1.5 to 3.5
	Loring	Silt loam	Moderate	2.0 to 6.0	6.0 to 12.0
	Wellston	Heavy silt loam	Moderate	>6	3.0 to 6.0
	Zanesville	Silt loam	Moderate	2.0 to 2.5	4.0 to 6.0

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*Moderate permeability = 0.63 to 2.0 inches per hour.

Source: USDA Soil Conservation Service, Soil Survey of Daviess and Hancock Counties, Kentucky (1974).

Table 4.3-2. Potential for Adverse Effects to Groundwater and the Terrestrial Food Chain from Seepage from Unlined Ash and Sludge Waste-Disposal Sites

Factor	Relative probability of	
	Groundwater contamination	Food chain contamination via soil
Nature of waste		
Dry	Low to moderate	Low to moderate
Slurry	High	High
Acid	High	High
Alkaline	Low to moderate	Low to moderate
Nature of substrata[a]		
Granite	Extremely low	Not applicable
Shale	Low	Not applicable
Sandstone	Moderate	Not applicable
Sand	High	Not applicable
Soil	High	High
Nature of soils		
Clays	Low	High
Loams	High	High
Sands, sandy loams	Very high	High to low
Rainfall zone[b]		
< 25 cm (< 10 inches)	Low	Low to high
25-76 cm (10-30 inches)	Low to high	High
> 76 cm (> 30 inches)	High	High, except for sandy areas

[a] Defined as the layer or layers of natural material beneath the waste, or between the waste impoundment and the groundwater aquifer.

[b] Annual average precipitation.

Source: Fish and Wildlife Service (1978).

soils. When the seasonal water table is less than 9.9 feet from the soil surface, the area is usually considered a poor site for ash and sludge waste disposal (FWS 1978). Table 4.3-1 shows that four of the soil types can have water tables as shallow as 0.5 feet from the surface. Only soils in the Frondorf and Wellston series having water tables greater than 6 feet deep could have levels approaching the 9.9 foot depth. Thus, some infiltration of trace elements from solid waste landfill areas appears likely, even though the waste will be deposited in a dry state. Over the long term, trace element concentrations in plants will increase, with the degree of physiological disturbance dependent on existing concentrations (see Subsection 4.3.3.1). Toxicity is not expected based on known characteristics of fossil fuel power plant solid wastes (currently excluded from hazardous waste regulations).

Leaching from the uncovered, unlined coal and limestone storage piles and retention basins is also probable. The pH range for soils in these areas is 4.5 to 6.0, making them slightly acidic and sensitive to alkaline leachate.

A possible difficulty in construction of holding ponds A and B is depth to bedrock. The estimated depth of these ponds is 12.5 feet, but the Belknap soil type may have bedrock as shallow as 7 feet (Table 4.3-1). Pond C is in a tenuous location because it borders the 100-year flood elevation (406.3 feet msl) at Sandy Branch. This pond has a closed water cycle and is to be used for coal and limestone pile runoff and the SO_2 removal, bottom ash, and waste stabilization systems. It will be of sufficient capacity to hold maximum waste streams from once-in-10-year, 24-hour rainfall plus a 1-foot freeboard. Surface water flooding will be controlled by planned capacity and a system that will bypass a retention basin and take stockout pile runoff directly to Sandy Branch. Groundwater quality will be monitored at the location.

Existing trace element loads of soils of the Hancock site are unknown but likely are at least moderate based on numerous emissions sources in the vicinity of the site. Operation of the Hancock Generating Station will increase concentrations in an incremental step toward high levels.

4.3.2.2.2 Transmission System

Unit 1. Soil profiles will be disrupted, topsoil lost, and subsoil mixed and compacted during construction at tower locations. Compaction and erosion will occur on access roads built from existing highways to the transmission line right-of-way. Some erosion and runoff will also occur near towers as they are constructed. Since the right-of-way crosses numerous ridges, the possibility exists for major soil loss from erosion along the steeper slopes.

Unit 2. Soil impacts will not be so extensive on the Elizabethtown corridor because access roads, for the most part, already exist, and the topography has less relief than that of the north-south corridor.

4.3.2.3 Breckinridge Site Alternative

Approximately 1125 acres of known prime farmland soils will be lost in the construction of the generating station on the Breckinridge site. Extent of known non-prime farmland soils that will be disrupted and will no longer support the pasture and woodland communities currently present is approximately

875 acres. Approximately 500 acres of undetermined soil types will also be irreversibly altered during construction and operation of the plant.

4.3.2.3.1 Generating Station

Construction. Construction impacts on soils will be similar to those on the Hancock site. Destruction of the soil profile, disruption of natural contouring, and increased erosion will occur.

Operation. Expected effects on soils characteristics from operation of the generating station are generally similar to those expected on the Hancock site. However, incompleteness of the soil survey, as well as incomplete engineering plans for the Breckinridge site, limits comparable evaluation of soils impacts. The potential for leaching and seepage of effluents cannot be determined at this time since permeability, depth to water tables, and identification of all soil types are not available.

Although most of the soils on the site are silt loams, some gravelly and stony soils not found on the Hancock site are present in the landfill areas. These soils are more permeable than clays or silty soils but their limited extent precludes significant high-probability leaching. As on the Hancock site, high rainfall and predominance of silt loam soils makes some infiltration of trace elements from solid waste landfill area appear likely, even though, again, the waste will be deposited in a dry state and the stabilized product generally is considered nonhazardous.

The steepness of slopes in the landfill areas will necessitate frequent benching to reduce surface erosion. Although the levels of trace elements in the soil are also unknown on this site, the greater distance from existing emissions sources suggests lower concentrations currently in the soil.

4.3.2.3.2 Transmission System

Unit 1. Soil disturbance will be similar to that expected for Unit 1 in the Hancock site alternative. Soil profile disruption, topsoil loss, compaction, and erosion will occur during construction. The topography of this transmission corridor is generally less hilly, which should reduce erosion. Also, the greater extent of existing access roads should reduce road construction and lessen the amount of land affected by compaction and erosion.

Unit 2. The principal difference between construction of Unit 2 from the Breckinridge site and Unit 2 from the Hancock site is the somewhat lesser extent of land disturbed. The Breckinridge Unit 2 right-of-way will be 5 miles shorter but, again, this 5 miles would be widening of the existing corridor so that greatest effects will occur in locations where towers are placed, and the impact will be minimal compared with newly developed areas.

4.3.3 Vegetation

The primary impact to vegetation from construction and operation of the generating station will be the permanent loss of existing vegetation on most of the site and the incremental regional loss as industrial land use increases. Cover types that are able to establish on the reclaimed landfill areas will have lower economic, wildlife, and nutrient value than those currently existing in the sites' riparian and upland areas especially. Increased pollution levels will affect both onsite and offsite pollution-sensitive vegetation.

4.3.3.1 General Effects in Vegetation Communities and Vegetation Stress

Those vegetation communities that will not readily establish on the sites because of topographic and soils alterations include lowland hardwoods, wet-site and marshy communities, and wetlands. Upland species and associations that will not reestablish because of their dependency on deep and fertile, as well as moist soils, include beech, maples, basswood, and yellow buckeye. Black walnut, white oak, and northern red oak may return but will not have suitable conditions for optimum growth and dominance in the community. Understory species that will not reestablish in lowland or upland woodlands include wingstem, lopseed, false nettle, spring ephemerals, ferns, pawpaw spice-bush, hydrangea, and American hornbeam.

Initial reclamation from planting or seeding followed by natural revegetation will result in invasion of pioneer species such as Japanese honeysuckle, blackberry, eastern redcedar, sumac, black locust, and sassafras. There will be a successional shift from climax stage woodlands to pioneer stage old fields. If climax communities develop, they will comprise species associated with drier, shallow soils typical of post-disturbance oak-hickory forests of the project area.

Economic benefits from agricultural species will not only be lost during the operational period of the plant, but will be diminished on the post-generating station site because productivity will be diminished. Vegetation removal plus burning of slash and unmerchantable timber during site development will result in organic and inorganic nutrient loss that will affect natural productivity for many years.

Optimum growth of vegetation on the site during operation of the plant will be affected by erosion and soil loss occurrng during construction as well as particulate fallout such as limestone dusting. These effects probably will be limited to the site area. Based on expected 24-hour maximum particulate levels of 170 micrograms per cubic meter 1000 feet from the plant, they will be minor since impacts generally occur at deposition rates of 1 gram per meter^2 per day (FWS 1978).

Leaching from solid waste landfills will increase concentrations of trace elements and other chemicals in the soil at least minimally. Like disturbances, this could also limit nutrient uptake. Although toxicity levels for most species are not expected (most are unknown), studies indicate that certain levels of various trace elements in plant tissue in general probably are harmful (Table 4.3-3). Existing levels of the trace elements on the sites are unknown, as is the leaching potential of the newly-developed stabilized waste product. However, as mentioned, the stabilized product generally is considered to result in minimal leachate and to be nonhazardous.

The primary air pollutants that could affect vegetation are SO_2, NO_2, and particulates. Additionally, salt drift deposition from the cooling towers has potential effects on vegetation. Exposure to these airborne effluents may cause acute, chronic, or latent injury to plants. Acute injury is due to high concentration, short-term exposure that results in the rapid development of visible tissue necrosis. Chronic injury, which usually develops more slowly

Table 4.3-3. Normal Range and Suggested Maximum Concentrations of Chemical Elements in Plant Leaves[a]

Element	Concentration (ppm, dry wt)	
	Range	Maximum
Arsenic	0.1-1.0	2
Barium	10-100	200
Boron	7-75	150
Cadmium	0.05-0.20	3
Cobalt	0.01-0.30	5
Copper	3-40	150
Chromium	0.1-0.5	2
Fluorine	1-5	10
Iodine	0.1-0.5	1
Iron	20-300	750
Manganese	15-150	300
Molybdenum	0.2-1	3
Nickel	0.1-1.0	3
Lead	0.1-5.0	10
Mercury	0.001-0.01	0.04
Selenium	0.05-2.0	3
Vanadium	0.1-1.0	2
Zinc	15-150	300

[a] Data of: Melsted, S. W. 1973. Proc. Joint Conf. Recycling Municipal Sludges Effluents Land, pp. 121-128. (As cited by: Baker, D. E. and L. Chesnin. 1975. Chemical Monitoring of Soils for Environmental Quality and Animal and Human Health. Adv. Agron. 27:305-374.)

Source: Fish and Wildlife Service (1978).

over long-term, lower concentration exposures, results in chlorosis, abscission, and eventual death of the plant. Latent injury is more difficult to detect and usually results in gradual disruption of physiological plant processes and reduced reproductive viability due to low-level concentrations over many years of exposure. Variables and conditions influencing the degree of injury are described below.

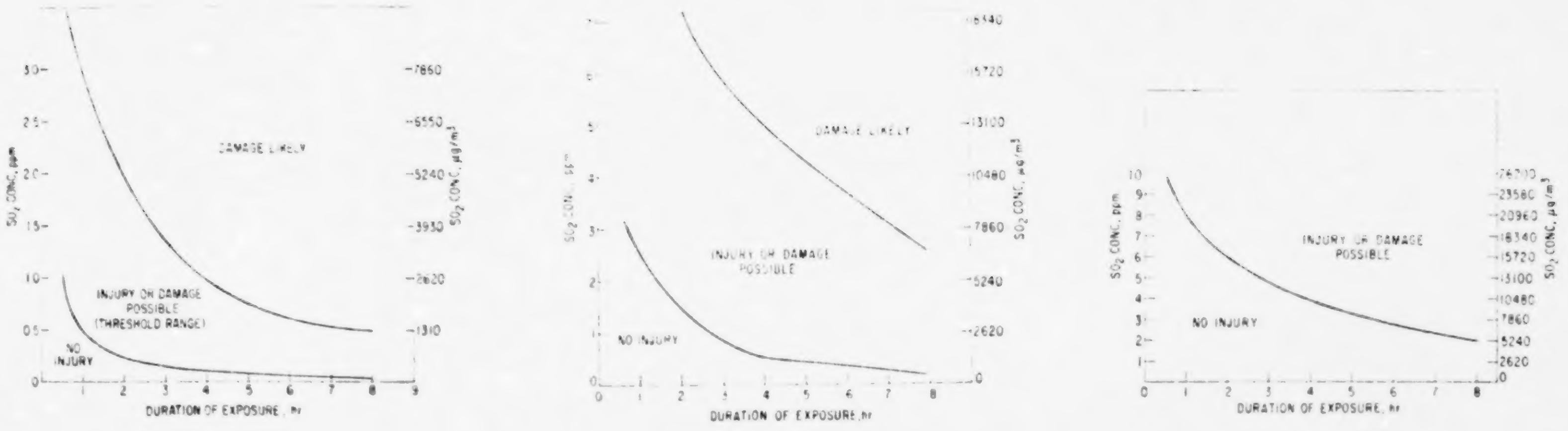
Plants are most susceptible to air pollution injury during spring and summer. This increases the possibility of injury near the generating station in the project area since peak operation and maximum levels of emissions from the proposed station and distant facilities occur in the summer. Other factors such as temperature, light, humidity, soil moisture and fertility, genetic susceptibility, extent of exposure, and synergistic interactions of pollutants can affect vegetation stress and damage.

Sulfur dioxide (SO_2) injury, although widely studied, is still difficult to predict. Research results on harmful pollution levels and plant injury often vary. Visible plant damage is easier to detect and quantify, although injury thresholds vary with species, length of exposure, concentration, and atmospheric conditions. Invisible or latent injury is more difficult to determine. Some past research has discounted the existence of invisible injury and concluded that temporary inhibition of photosynthesis is rapidly regained when leaves are not permanently injured; similarly, fumigations that do not visibly injure leaves do not reduce yields (Thomas and Hendricks 1956).

More recent findings show that long-term low-level exposure to SO_2 causes excessive sulfur accumulation in foliage of plants, which then generally manifest earlier leaf senescence and greater reductions in seed viability, percent seed germination, speed of germination, and mycorrhizal association (Rice et al. 1979). SO_2 damage undetected by leaf necrosis or other visible signs of injury is evident in aerial infrared photography. Indications are that at lower level SO_2 concentrations, damage may not be evident for 5 to 10 years. Thus, while visible plant injury may be predicted based on exposure levels, damage may be occurring at levels below the visible injury threshold and reducing the vitality of the affected plant communities.

Dose-injury curves in Figure 4.3-1 show probably damage thresholds for plant species that are sensitive, intermediate, and resistant to SO_2. The minimum threshold injury level for 3 hours of exposure is approximately 330 $\mu g/m^3$ (0.15 ppm) for sensitive species and 13,000 $\mu g/m^3$ (5.0 ppm) for resistant species. Table 4.3-4 lists, by SO_2-sensitivity groupings, the herbaceous plants, woody trees, shrubs, and ornamentals likely to occur in the vicinity of the generating station.

Injury from NO_2 usually occurs from synergistic effects with other pollutants rather than solely from NO_2 concentrations. Ambient levels of NO_2 are usually too low to cause injury, even to susceptible plants. However, combination of NO_2 with other pollutants (especially SO_2) produces injury at concentrations lower than would have occurred with either pollutant alone. Threshold curves for injury solely from NO_2 concentrations are shown in Figure 4.3-2, and a listing of recorded sensitive plant species are given in Table 4.3-5. Minimum exposure thresholds for metabolic and growth effects are approximately 1.5 mg/m^3 (1500 $\mu g/m^3$) for 1 hour and 0.8 mg/m^3 (800 $\mu g/m^3$) for 3 hours. Expected levels during operation of the generating station are below these minimum thresholds. Chronic exposure to NO_2 levels as low as 1.0 mg/m^3



Dose-Injury Curves for SO_2-Sensitive Plant Species.

Dose-Injury Curves for Plant Species of Immediate SO_2-Sensitivity.

Dose-Injury for SO_2-Resistant Plant Species.

Adapted from: U.S. Environmental Protection Agency. 1973. Effects of Sulfur Oxides in the Atmosphere on Vegetation. Rev. Chap. 5 for Air Quality Criteria for Sulfur Oxides. EPA-R3-73-030; PB-226 314.

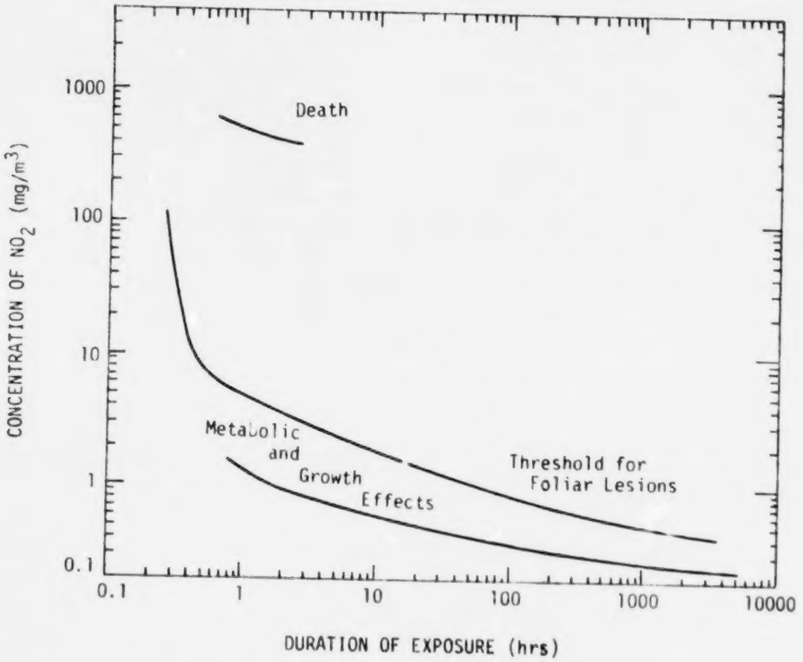
SOURCE: Fish and Wildlife Service (1978)

Figure 4.3-1. Dose-Injury Curves for Plant Species Sensitive, Intermediate, and Resistant to SO_2

Table 4.3-4. SO_2 Sensitivity Groupings for Vegetation in the Hancock Study Area

Sensitive		Intermediate		Resistant	
Scientific Name	Common Name	Scientific Name	Common Name	Scientific Name	Common Name
Abrosia artemisiifolia	Ragweed	*Acer negundo*	Boxelder	*Acer platanoides*	Maple, Norway
Aster sp.	Aster	*Acer rubrum*	Maple, red	*Acer saccharinum*	Maple, silver
Convolvulus arvensis	Bindweed	*Aster* sp.	Aster	*Acer saccharum*	Maple, sugar
Cucurbita maxima	Squash	*Hydrangea paniculata*	Hydrangea	*Cornus florida*	Dogwood
Delphinium sp.	Larkspur	*Picea engelmannii*	Spruce, Engelmann	*Cynodon dactylon*	Grass, bermuda
Erigeron canadensis	Fleabane	*Picea glauca*	Spruce, white	*Ginkgo biloba*	Ginkgo
Festuca rubra	Fescue, red	*Pinus echinata*	Pine, shortleaf	*Ilex aquifolium*	Holly, English
Fraxinus americana	Ash, white	*Poa annua*	Bluegrass, annual	*Juniperus* sp.	Juniper
Fraxinus pennsylvanica	Ash, green	*Poa pratensis*	Bluegrass, Kentucky	*Ligustrum* sp.	Privet
Glycine max	Soybean	*Populus deltoides*	Cottonwood, eastern	*Nyssa sylvatica*	Black gum
Liriodendron tulipifera	Yellow poplar	*Prunus virginiana*	Chokecherry	*Oxydendron arboreum*	Sourwood
Lycopersicum sp.	Tomato	*Quercus alba*	Oak, white	*Picea pungens*	Spruce, blue
Malus sp.	Apple	*Rosa* sp.	Rose	*Platanus occidentalis*	Sycamore
Parthenocissus quinquefolia	Virginia creeper	*Syringa vulgaris*	Lilac	*Quercus palustris*	Oak, pin
Phaesolus vulgaris	Bean	*Tilia americana*	Basswood	*Quercus rubra*	Oak, northern red
Pinus resinosa	Pine, red	*Ulmus americana*	Elm, American	*Rhus glabra*	Sumac, smooth
Pinus strobus	Pine, white	*Viburnum* sp.	Snowball bush	*Rhododendron* sp.	Rhododendron
Pinus sylvestris	Pine, scotch			*Robinia pseudoacacia*	Black locust
Pinus virginiana	Pine, Virginia			*Salix* sp.	Willow
Plantago major	Plantain			*Thuja occidentalis*	Arborvitae
Poa sp.	Bluegrass				
Polygonum sp.	Smartweed				
Prunus persica	Peach				
Prunus serotina	Black cherry				
Pyrus communis	Pear				
Rubus sp.	Blackberry				
Rumex crispus	Curly dock				
Rumex sp.	Sorrel				
Salix nigra	Willow, black				
Solanum sp.	Nightshade				
Solidago sp.	Goldenrod				
Taraxacum officinale	Dandelion				
Tricticum aesativum	Wheat				
Ulmus parvifolia	Elm, Chinese				
Vicia sp.	Vetch				
Xanthium sp.	Cocklebur				

Sources: Fish and Wildlife Service (1978).
Kenaga (1974).



Adapted from: National Research Council, Committee on Medical and Biological Effects of Environmental Pollution. 1977. Nitrogen Oxides. National Academy of Sciences, Washington, D.C. (originally from MacLean 1975).

SOURCE: Fish and Wildlife Service (1978)

Figure 4.3-2. Dose-Injury Curves for NO_2 Exposures

Table 4.3-5. Species Recorded as Sensitive to NO_2

Scientific Name	Common Name
Acer palmatum	Japanese maple
Acer platanoides	Norway maple
Ginkgo biloba	Ginkgo
Lactua sativa	Lettuce
Malus sp.	Apple
Nicotiana glutinosa	Tobacco
Petunia hybrida	Petunia
Picea glauca	White spruce
Picea pungens	Blue spruce
Pinus mugho mughus	Dwarf mugho pine
Pinus nigra	Austrian pine
Pinus strobus	White pine
Pyrus communis	Pear
Rhododendron sp.	Azalea
Robina pseudoacacia	Black locust

Source: Kenaga (1974).

(1000 $\mu g/m^3$) has produced injury (FWS 1978), but these levels still are above those expected around the plant site.

Particulate emissions deposited on leaf surfaces can block stomata, interfere with gaseous exchange, and disrupt heat-exchange pathways (FSW 1978). Fly ash contains a number of trace elements that can be injurious to vegetation if concentrations in the soil already are high. The 600-foot height of the Hancock Station stacks will disperse and dilute particulate emissions, reducing deposition around the plant. Impacts will depend on trace element concentrations already present in the soils. Low-level addition of elements lacking in the soil may increase plant growth, while input of elements already present in high concentrations may exceed toxicity levels (FSW 1978). Forests have greater leaf surface available for deposition and assimilation of substances dispersed in the atmosphere and deposited as precipitation. Additionally, smaller amounts of essential nutrients are required for sustained-yield forest management than for sustained-yield agriculture, making forests more sensitive to increased trace element deposition (Cowling 1979).

The impact of salt drift from cooling towers will be greatest in the immediate vicinity of the generating station. It is expected to be insignificant in locations greater than 150 feet from the cooling towers. Plant injury involving scorching or necrosis of leaves is exhibited when salt concentration thresholds are exceeded. Plant vigor is reduced, and mortality may occur. Salt accumulations of 100 to 200 ppm may cause injury to vegetation (FWS 1978).

4.3.3.2 Hancock Site Alternative

4.3.3.2.1 Generating Station

Construction. Development of the Hancock site will remove these extents of existing vegetation:

1479 acres - cropland and pasture
494 acres - upland hardwoods
196 acres - lowland hardwoods
105 acres - old fields
4 acres - wetlands

Cover types occupying areas of the generating units and ancillary facilities are primarily crops, pasture, and lowland hardwoods. Economic loss of cultivated fields and woodlands on the site was discussed in Section 4.1.2.

In addition to loss of continuing timber maturation and future harvest, clearing of the lowland hardwoods will remove a valuable wildlife habitat. Grading and filling of the small wetland on the northern portion of the site will remove habitat that is more unique and environmentally sensitive than the lowland hardwoods. The valuable habitat diversity provided by both vegetation types will be permanently altered.

Operation. During the operation phase, additional vegetation cover, primarily upland hardwoods, will be removed as landfill areas are developed. Although these woodlands have been selectively harvested in the past, much commercially valuable timber is present on the site. As in the lowland hardwoods, harvest of existing trees will reduce economic loss, but future production and time required for reestablishment of similar woodlands is irreplaceable. Also, loss of these hardwoods will eliminate valuable forage and cover for wildlife (see Section 4.3.4).

Oak-hickory forests are a common association in the region and reestablishment of this cover type, although far in the future, may be possible, depending on the degree of substrate alteration. However, the mixed mesophytic association found on the Hancock site is not common in the region and will not reestablish on disturbed land because it is highly site dependent. Deep, moist, well drained soils with high fertility and well developed profiles are necessary site factors for these forests. Clearing and filling the ravine slopes that are now occupied by the mixes mesophytic forest will permanently destroy this habitat and preclude the successional return of this association.

Based on soil properties and expected leaching and seepage, at least a minimal increase in trace element uptake by plants may be expected. The impact of this will depend upon existng concentrations. A minimal increase probably will not result in toxic levels although stress is possible.

Maximum observed 3-hour SO_2 concentration on the Hancock site during KU's monitoring program was 632 $\mu g/m^3$. Using the estimated maximum 3-hour SO_2 value from KU's PSD application indicates a possible 3-hour maximum SO_2 level of 846 $\mu g/m^3$, which is within the range of possible damage to sensitive plant species (Figure 4.3-1). The predominantly southerly and southwesterly winds on the site will increase the possibility of plant stress north and northeast of the site. Sensitive species of commercial concern in this area include soybeans near the site and white and red pine stands in Hoosier National Forest across the Ohio River. Exact predictions of injury to these and other species in the area cannot be made, but there is a small possibility of chronic or latent injury to sensitive species from relatively high levels of SO_2 already present.

Concentrations of NO_2 are not expected to reach levels that would cause damage from this emission alone. Combinations of SO_2 and NO_2 that will cause injury are unknown, but injury to sensitive species is possible since these levels are lower than injury-causing levels for either emission alone. Known sensitive commercially important species in the area include white pine and tobacco.

Threatened and Endangered Species. No Federally threatened or endangered species were observed on the Hancock site during vegetation surveys (see Section 5.0), nor are records existing (FWS, personal communication 1980; Kentucky Nature Preserves Commission, personal communication 1980). However, ginseng (Panax quinquefolium), which is on the Kentucky Nature Preserves Commission plant element list, is locally reported present in the Jeffry Cliff area. Although Federal or state listed species have not been sighted, suitable habitat for some of the species, including ginseng, is present on the site. The Jeffry Cliff area is the most biologically unique habitat on the site and is the most likely area for threatened and endangered species to exist.

4.3.3.2.2 Transmission System

Unit 1. The primary impact of transmission line construction on vegetation will be loss of tree cover along the corridor. Additionally, disturbance of shrubs and ground cover will occur, with greatest impact on these species in forested areas as well. Croplands, pasture, and old fields will have little loss of vegetation except in areas occupied by towers.

As on the site, vegetation removal will result in nutrient loss and increased surface water runoff. Erosion control practices and selective clearing techniques to be employed in sensitive areas, such as stream crossings, will reduce but not completely eliminate stress on terrestrial and aquatic communities. The extensive woodlands and hilly terrain of this corridor will require more tree removal and will be overall more susceptible to runoff than would the Breckinridge Unit 1 corridor.

During operation of the transmission system, much vegetation growth will be controlled by aerial application of herbicides. Drift from application can contaminate nontarget areas, causing injury to sensitive plants. Although ozone that is produced around high-voltage electrical transmission lines and substations is believed to be associated with stress (Oak Ridge National Laboratory 1974), concentrations related to the proposed line are not expected to impact vegetation.

Unit 2. Vegetation impacts along the Unit 2 corridor will be similar in kind to those along Unit 1. Although most of the corridor has already been cleared for the existing transmission line, additional vegetation will be removed when the corridor is widened. Most of the land that will be disturbed is agricultural (see Section 4.1.2).

Areas of greatest potential disturbance and biological impact are stream crossings and the wetland area around Hicks Lake (Figure 4.3-3). Impacts will be reduced if these habitats are spanned at sufficient height and have sufficient tower spacing so that vegetation will not be cleared and hydrological aspects of the wetland area especially will not be disturbed. Herbicide use should be restricted in this area and near stream crossings to prevent contamination from drift.

4.3.3.3 Breckinridge Site Alternative

4.3.3.3.1 Generating Station

Construction. Development of the Breckinridge site will remove:

1430 acres - cropland and pasture
901 acres - upland hardwoods
58 acres - lowland hardwoods
52 acres - old fields

Again, cover types that will be replaced by the power plant and facilities are crops, fields, and lowland types. The value of cropland and pasture losses is discussed in Subsection 4.1.2. Disturbance-sensitive cover types in low-lying areas occupy fewer acres on the Breckinridge site than on the Hancock site, so economic and habitat losses are less.

Operation. Clearing and filling of ash and sludge disposal areas on the Breckinridge site will destroy the upland hardwoods presently occupying higher elevations of the site. Although these forests have been high-graded in the past, commercially valuable timber is still present. As on the Hancock site, harvest of merchantable timber, while reducing economic loss, cannot offset time lost from future timber production.

The upland hardwoods on the Breckinridge site are primarily oak-hickory associations, although small almost pure sugar maple stands are present on areas that appear to have been extensively high-graded or otherwise disturbed in the past. Future reestablishment of existing upland forest associations on this site, although far away timewise and successionally, appears to be more feasible than on the Hancock site since no mixed mesophytic-type associations were observed here.

Probability of stress from leaching and runoff of limestone storage piles, ponds, and waste disposal areas cannot be predicted until the soil survey for this area is completed. The steep slopes in the landfill areas increase the possibility of runoff and stress to vegetation in buffer zones.

Ambient concentrations of SO_2 are lower on the Breckinridge site and addition of expected emissions from the generating station, although higher than expected from the Hancock plant, indicate concentrations will still be below those on the Hancock site. The potential 3-hour maximum concentration of 520 $\mu g/m^3$, while lower than on the Hancock site, is within the threshold for possible injury to SO_2-sensitive species (Figure 4.3-1). Acute or chronic plant injury from SO_2 is less likely than on the Hancock site. Latent damage from long-term exposure cannot be predicted, but the lower concentrations makes the possibility of injury less on the Breckinridge site. Sensitive species of commercial concern in the area include soybeans and white and red pine on the Indiana side of the Ohio River.

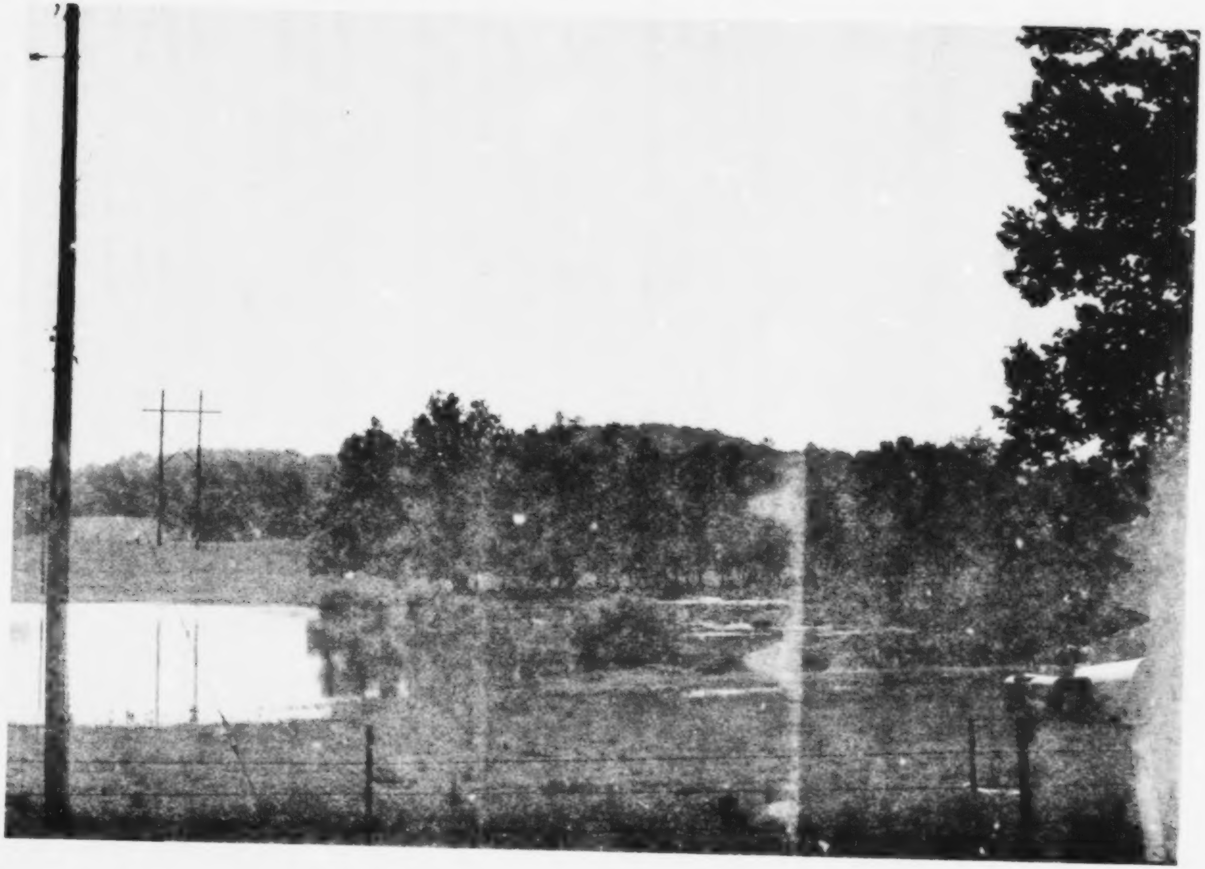


Figure 4.3-3. Hicks Lake Wetland Area, Elizabethtown Transmission Corridor, 1980

Damage from NO_2 concentrations is not anticipated, although injury levels from interaction with SO_2 are not known. Sensitive species for NO_2 injury are similar to those on the Hancock site.

Construction of the proposed synfuel facility adjacent to the site would raise levels of all atmospheric pollutants at least to the level expected on the Hancock site and probably higher.

Threatened and Endangered Species. No threatened or endangered plant species were observed on the Breckinridge site although potential habitat for species occupying marshy and woodland locations is present. French's shooting star (Dodecatheon frenchii), which is on the Smithsonian Institution's (1975) list of threatened plants and a possibility for DOI listing, is the only threatened or endangered species recorded for Breckinridge County (FWS Region IV, personal communication 1980). This perennial herb grows along moist shaded cliffs. It was not observed during vegetation sampling (methodology in Section 5.0) and was not listed in a floristic survey of the county. A congener, the common shooting star (Dodecatheon meadia), has been sighted on the bluffs near Stephensport (Ratliff, personal communication 1980).

4.3.3.3.2 Transmission System

Unit 1. The principal vegetation impact from construction of Unit 1 transmission facilities south from the Breckinridge site will be loss of forest vegetation along the right-of-way. Although woodlands, again, will be the most severly impacted, forested areas are less extensive on this corridor than on the Hancock corridor. The greater proportion of agricultural lands and the more gently rolling terrain and better road access makes timber removal and erosion stress less of a problem on this corridor. Vegetation along the numerous streams crossing the corridor could be severly disturbed if not well protected. A similar potential for stress from herbicide drift exists on this corridor, although potential for reducing the extent of stress is greater on this corridor where selective routing of the line can avoid forested areas. Again, ozone emissions are expected to be insignificant and not harmful to nearby vegetation.

Unit 2. Impacts from construction of the Breckinridge Unit 2 transmission corridor will be the same as those from the Hancock alternative except for the 5 mile difference shorter length. Connecting the corridors east of Cloverport will reduce the amount of vegetation cleared and the potential for stream disturbance. Estimates of acreage differences are given in Section 4.1.2.

4.3.4 Wildlife

Habitat degradation associated with noise, dust, traffic, and other elements of human activity, as well as habitat loss associated with forest clearing or other land use change will impact wildlife of the project area. The decline in wildlife diversity that generally accompanies habitat degradation and habitat loss will be preceeded by mortality of numerous individuals during land clearing activities. Some populations will recover, but these generally will be widespread, common species. These impacts will begin during construction of the plant and will continue throughout the life of the plant as landfill areas are worked and toxic substances are emitted. Probable continued industrial use of the site beyond the life of the generating station will maintain the life support value of the land at a diminished level, reducing its long-term biological productivity.

4.3.4.1 General Effects

The immediate result of land clearing for construction of plant facilities will be an overall reduction in the populations of most wildlife present. Animals with limited mobility (e.g., mammals, reptiles, amphibians) will be killed. Animals with greater mobility will move into adjacent habitat, but populations eventually will decline because of continued habitat loss and increased competition. Comparatively few species will occupy areas around the plant facilities; more species will occupy revegetated landfill areas, but several decades of uninterrupted succession and establishment of drainage patterns would be necessary to approximate present conditions.

Similar effects will occur during right-of-way development for transmission system construction, but intense human activity will be short-term and future habitat management potential is greater in the transmission corridor.

Herpetofauna. As a group, herpetofauna will experience considerable impact from site and transmission development. Indications are that herpetofauna already are impoverished on the Hancock and Breckinridge sites, probably in response to tree harvesting and cultivation activities. As shown by this response and others (Blymer and McGinnes 1977), recovery of these species from increased mortality will be minimal and restricted to areas of limited human activity and where suitable breeding habitat and food are available.

Birds. Although direct mortality of birds from land clearing activities will be limited primarily to nestlings, bird usage of the site will diminish as hardwood habitats, where abundance and diversity currently are greatest, are displaced. Woodpeckers, warblers, and vireos are among the species that will decline. The house sparrow, starling, red-winged blackbird, brown-headed cowbird, and other disturbed-area species will continue to utilize the site, some in greater numbers than at present. Populations of the two upland game birds observed on the sites, the bobwhite and mourning dove, will be reduced, although both are expected to utilize revegetated landfill areas. Wading birds will be adversely affected, but few utilize the sites presently. Waterfowl and shore birds, which also are uncommon on the sites and the adjacent Ohio River, may be attracted to retention basins and holding ponds for resting sites.

Construction of the transmission corridor through forested areas may produce ecotones that are compatible with birds in general, but again, certain perching birds and woodpeckers may be reduced. Edge habitats created by clearcuts (including rights-of-way) often support greater species diversity than either of the adjacent habitats alone (Thomas et al. 1977). However, a transmission corridor is different from many types of clearcuts, having a low ratio of width to length (Thompson 1977). The seral habitats developing on these narrow edges differ in physiogonomy from the adjacent forest but often differ little in plant species composition from the forest understory. In such cases, and others, edge habitat may not support greater numbers of species than adjacent habitat with greater stratification (MacArthur and MacArthur 1961). Recent studies of bird utilization in eastern deciduous forest (Anderson et al. 1977) indicated that bird diversity was lower in a corridor than in undisturbed forest, even though most forest species appeared to be attracted to the corridor.

In western coniferous forests (Thompson 1977), little or no increase in total numbers of bird species along rights-of-way was noted, although increases in the number of common species were frequent.

Bird species that may be expected to increase along the right-of-way are upland game birds, common fallow field inhabitants such as the Savannah sparrow and eastern meadowlark, and common open woodland species such as the mockingbird, American robin, and common crow. Corridors the width of those proposed (150 to 250 feet) may be colonized by typical open-habitat species, although summer residents rather than year-round species may be most likely to do so (Anderson et al. 1977). Several species of raptors will use the transmission lines and towers for hunting perches and possibly for nest support structures. Because of good eyesight, raptors are rare wire-strike victims compared with waterfowl and other bird groups. Due to their high speed and low altitude flights, teal and diving ducks apparently are especially susceptible to collisions with overhead wires. Waterfowl strikes are most frequent during migrations and are most likely near feeding, nesting, or resting places and on ridges where flights may be near the ground.

Mammals. Mammals expected to remain near the plant include small mammals adapted to fallow field vegetation (e.g., meadow vole, short-tailed shrew) and larger species adapted to open and shrub habitats (e.g., opossum, striped skunk). Mid-size and large species that require forested security areas (e.g., white-tailed deer) or trees for food and nesting (e.g., gray squirrel) will decline in the area of the plant. The house mouse probably will increase in abundance in the plant facilites, and the Norway rat may become established.

Edge habitat in forested areas along the transmission corridor probably will increase mammal usage by common species having a broad range of tolerances, high dispersal ability, and high reproductive rates (Thompson 1977). In the project area, these species include those fallow field, open, and shrub inhabitants mentioned above, as well as the woodchuck, eastern cottontail rabbit, eastern mole, and eastern chipmunk. Additional browse probably will be available for the white-tailed deer, with the extent depending upon the type of habitat cleared. Moist sites generally produce denser shrubby vegetation than do drier forest locations. Lowland hardwoods are sparse along the Hancock and Breckinridge corridors and additional browse would have to be planted and managed in most locations. The Elizabethtown corridor currently is not managed for wildlife usage, so little benefit to the deer is anticipated.

The impact of construction-related displacement on mammal and other wildlife carrying capacity along the transmission corridor will be short term compared with that occurring on the plant site, where displacement will continue during plant operation. However, right-of-way maintenance practices influence establishment of shrub vegetation and can preclude utilization by several wildlife species if indiscriminate. Most of the herbicide-related stress noted along the Elizabethtown corridor was in moist-site locations where shrub density and wildlife utilization could be greatest.

Threatened and Endangered Species. Although no Federally threatened and endangered wildlife were observed in the project area during wildlife surveys (see Section 5.0), two species, the Indiana bat and gray bat, could occur there. However, onsite survey data and biological requirements indicate they do not occur on the sites and will not be affected by the project. Population of the gray bat, whose range includes parts of Kansas, Oklahoma, Arkansas, Illinois, Indiana, North Carolina, Georgia, and Florida, and most of Missouri, Kentucky, Tennessee, and Alabama, is around one million (FWS/OBS-80/01.42). Remaining population of the Indiana bat is about one-half that of the gray bat. This bat is more widespread than the gray bat, ranging from New Hampshire to Iowa to eastern Oklahoma, and southeast to the Florida panhandle (FWS/OBS-80/0.123). Ranges of both species include the four study area counties: Perry County, Indiana and Hancock, Breckinridge, and Hardin Counties, Kentucky.

Caves and nearby aquatic habitat are important to both species. Both overwinter in caves, and the gray bat nests and roosts in caves during other seasons as well. Males of the Indiana bat also roost in caves during other seasons, but females and juveniles occupy nursery roosts under tree bark in riparian and floodplain areas. Both species forage soft-bodies insects -- the gray bat flying from cave to a river or lake and foraging mayflies especially, and the Indiana bat foraging flies in riparian vegetation and lowland forests. Foraging areas for the Indiana bat range from approximately 3.5 acres in early summer to 11 acres in late summer. Feeding-area requirements for the gray bat are unknown. Winter cave requirements for the Indiana bat are stable, cool temperature (4° to 8°C) and high humidity. The gray bat requires good air flow in deep, cool (6° to 9°C), multientranced caves; this migratory species arrives at the winter caves in September.

Two caves in Kentucky have been designated critical habitat for the Indiana bat (42 FR 40687): Bat Cave in Carter County, which is in the northeast corner of Kentucky near West Virginia, and Coach Cave in Edmondson County, which is south of the project area and contains most of Mammoth Cave. Five other caves in Edmondson County are the remaining known habitats for the Indiana bat in the state. Critical habitat for the gray bat has not been established, but no major winter caves have been identified in Kentucky. Human disturbance of roosting and hibernating caves is the primary cause of gray bat decline throughout its range. Human disturbance and, in Kentucky, flooding, are reasons for the endangered status of the Indiana bat.

Suitable cave habitat for the gray bat has not been found on the Breckinridge site or the Breckinridge corridor. Both the site and corridor contain suitable feeding areas for the gray bat but apparent absence of nearby cave habitat diminishes the likelihood of its presence. The Hancock site and corridor contain habitat for the evening bat, but caves similar to those required by either of the endangered bats, especially the gray bat, have not been observed. Should Jeffry Cliff and similar ridges be suitable summer habitat for the Indiana bat, scarcity of suitable feeding areas would be a limiting factor, though not an excluding one. Based on feeding area requirement of 11 acres per animal in late summer, lowland hardwoods on the Hancock site would support only 17 Indiana bats.

4.3.4.2 Hancock Site Alternative

4.3.4.2.1 Generating Station

Wildlife expected to receive greater impact on the Hancock site than on the Breckinridge site include salamanders, lizards, birds of prey, migrant perching birds, nongame mammals, and furbearers. Species on the Kentucky Nature Preserves Commission Animal Element List expected to receive greater impact on the Hancock site are the evening bat and the black vulture.

Jeffry Cliff and adjacent woodlands provide habitat for several of the species expected to receive greater impact on the Hancock site. Other habitat differences that account for greater abundance and/or diversity of these species on the Hancock site are a greater extent and distribution of riparian and lowland hardwoods (3 streams and 180 acres on the Hancock site vs. 1 stream and 58 acres on the Breckinridge site) and the presence of a small marsh on the Hancock site. Site development will fill the marsh and clear most lowland hardwoods and hardwoods adjacent to Jeffry Cliff except those at the southwest corner. Despite a 500-foot clearance of Jeffry Cliff, carrying capacity of remaining upland hardwoods associated with the ridge will be reduced and wildlife diversity will decline. The precise response of the evening bat and the black vulture, both inhabitants of the ridge, cannot be predicted, but decline or elimination are potential impacts.

Also contributing to an overall greater impact to wildlife from the Hancock site alternative is the limited opportunity for ground-level emigration from the site as development proceeds. The Ohio River, industry, and highways virtually surround the site. These barriers will contribute to impact by causing Jeffry Cliff to become an island-like refuge area for many species.

4.3.4.2.2 Transmission System

Unit 1. The Hancock transmission corridor will cut through a ridge formation similar to Jeffry Cliff and a comparatively large area of forested habitat. Few roads presently exist in the corridor so that new human access to wildlife cover will increase and forested habitat will be reduced. These effects will be greater on this corridor than on the Breckinridge corridor. However, there are fewer major stream crossings on the Hancock corridor and disturbance to riparian habitats will be minimal.

Unit 2. Less disturbance to riparian habitat on the Hancock Unit 1 corridor would be offset by development of the Unit 2 transmission system from that corridor because of extensive riparian and aquatic habitats that lie between it and the Breckinridge corridor. Both the Hancock and Breckinridge Unit 2 transmission lines would have to be constructed across important riparian habitat associated with the Rough River and other streams but only the Hancock line would cross the Tar Fork/Clover Creek complex south of Cloverport. This complex appears to be the most important wading bird and waterfowl habitat in the project area. The potential for waterfowl strikes will increase because of additional towers and conductors.

4.3.4.3 Breckinridge Site Alternative

4.3.4.3.1 Generating Station

Herpetofaunal and avifaunal groups that will be affected more by development on the Breckinridge site include turtles, wading and shore birds, and waterfowl. Most of these species are associated with Town Creek and Town Creek embayment, although numerous small ponds with aquatic vegetation also provide suitable habitat. During construction of the plant and development of the landfill areas, these small ponds will be filled. Alteration of upper Town Creek, which drains the entire Breckinridge site, will further reduce productive aquatic habitat. The degree of impact occurring downstream in Town Creek embayment depends upon flow regulation from upper Town Creek and how much drift from upper Town Creek contributes to the food chain of the embayment. Two species on the Kentucky Nature Preserves Animal Element List were observed near the Town Creek Embayment: the great blue heron and the great egret. However, like waterfowl and other aquatic birds in general, these species appeared to use the site irregularly.

Mammals in general would receive considerably less impact on the Breckinridge site. Small mammal diversity and abundance are more limited on the Breckinridge site, as is abundance of several mid-size species, including important furbearers. Emigration of deer and other larger mammals would be easier from the Breckinridge site because only the western and northern portions of the site are bordered by the Ohio River and major highways. However, development of the proposed synfuel facility south of the Breckinridge site would pose a barrier to emigration in that direction. Synfuel development also would affect impact on Town Creek embayment.

4.3.4.3.2 Transmission System

Unit 1. Development of the Breckinridge transmission corridor would have less impact on displacement of forested wildlife habitat because more of the Breckinridge corridor is agricultural and because existing roadways, especially in forested areas, would reduce the extent of new access necessary to build and maintain the transmission system. However, the Breckinridge corridor has the potential for greater impact on riparian habitat, especially where it is crossed by Little Beech Fork of Clover Creek. Lowland hardwoods generally are sparse on both corridors, and Little Beech Fork is notable both for hardwoods riparian habitat and areas of gorge-like relief.

Unit 2. As indicated, continuation of the Unit 2 transmission system from the Breckinridge corridor to Elizabethtown would be shorter than from the Hancock corridor and would preclude potential impacts on extensive aquatic wildlife habitat that lies between the two north-south corridors.

4.4 WATER

Water resources that will be affected by the generating station and transmission system include onsite streams and groundwater (see Figures 3.1-6 and 3.1-7), the Ohio River (River Miles 702 to 722), streams along the north-south transmission corridor (see Figure 3.1-5), and streams along the Elizabethtown transmission corridor (see Figure 3.1-1[illegible]). The project-related effects on these water resources will be associated with water consumption, alteration of stream characteristics, discharges to surface water, and infiltration to groundwater.

4.4.1 General Effects on the Ohio River and Groundwater

Impacts to the Ohio River and groundwater systems that would be influenced by project-related activities will be demands on water availability and additions of chemical wastes and heat. The magnitude of such impacts to water systems generally is limited through plant design and operating procedures that intend compliance with policy and guidelines of regulatory authorities. Consistent with currently adequate regional water supplies, explicit controls on water demand through water rights or allocations are nonexistent. However, indirect ones are related to water quality controls and policy of the Ohio River Basin Commission (ORBC - created along with similar Commissions by the Water Resources Planning Act of 1965 (PL 89-80)). Controls on the nation's water quality are provided for by the Federal Water Pollution Control Act, as amended by the Clean Water Act of 1977 (33 U.S.C. 1251 et seq.), Safe Drinking Water Act of 1974 (PL 93-523, as amended), and Resource Conservation and Recovery Act of 1976 (RCRA) (42 U.S.C. 3251 et seq.). Pursuant to these Acts, this project must comply with Kentucky Water Quality Standards (401 KAR 5: 026, 029, 031, and 035), EPA's effluent guidelines and standards for steam electric power generation (40 CFR 423), and standards of the Ohio River Valley Water Sanitation Commission (ORSANCO). Subsection 1.3.2.8.6 and Tables 1.3-7 and 1.3-9 give these standards, and Tables 1.3-8 and 1.3-10 show effluents expected from the project.

The effects of the project on the Ohio River and on groundwater supplies are expected to be approximately the same regardless of which site is developed. Differences that are distinguishable are discussed under each site alternative.

4.4.1.1 Water Availability

4.4.1.1.1 Ohio River

The impact of withdrawal of cooling water makeup on various Ohio River flows (see Tables 3.4-4 and 3.4-5) will be:

Project Withdrawal[a]	Rate (cfs)	Ohio River Flow	Rate (cfs) RM 605.8-784	Project Percent
Maximum/ average	34/19	7-day, 10-year low[b]	12,975	0.26/0.15
		ORBC water quality critical flow	14,300	0.24/0.13
Average	19	1975 total consumption	71	26.8
		1975 power plant consumption	48	39.6
		Total increase consumption by 2020	663	2.9
		Increase in power plant consumption by 2020	605	3.1
Average loss to evaporation and drift	17	Average river flow	151,417[c]	.01

[a] Project withdrawals essentially represent consumptive use.
[b] Augmented low flow due to locks and dams.
[c] Taken from 1977-1979 data at Cannelton Lock and Dam rather than ORBC (1978).

The effects of the project on current and projected withdrawals from the stretch of the Ohio River adjacent to the site, where flow is controlled by the Cannelton Lock and Dam, are minor. The project will represent a 26.8% increase over recent total withdrawals in that part of the river and a 39.6% increase over recent withdrawals attributable to generating stations. Such large increases are within expectations of the ORBC for this part of the river, where consumptive use is projected to increase tenfold by 2020, compared with a fourfold increase in the Ohio River Basin as a whole. By then, the project will represent only about 3% of the projected increase in withdrawals attributable to power plants. Upon completion of planned (by 1985) reservoirs in the Ohio River Basin, 7Q10 low flow at the sites will increase to 14,200 cfs, and the impact of the Hancock project on that parameter of the river will be even less.

The insignificant impact of the project on Ohio River flows can be extended to similar impact on water availability for aquatic biota, wildlife, and recreation on the river. Water volume for navigation also will not be affected, although project structures in the river may increase navigation hazards, as discussed in Section 4.4.2. These structures will impact the other instream uses as well, primarily through temporary effects on water quality.

There will be an increase in usage of the Cannelton Lock and Dam by barges bringing coal from western Kentucky and southern Indiana and Illinois to the sites. The barges will represent approximately a 5% increase in traffic, but a small increase in lockage flow, assuming the daily average increase (7 to 8 barges) represents 1 or 2 tows. The maximum lockage rate of 56 barges requires less than 1% of the water that must pass through Cannelton Lock and Dam. Therefore, the additional barge traffic will have no detrimental impact on water for lockage.

4.4.1.1.2 Groundwater

Groundwater use from onsite wells will average 802 gpm (1.1 mgd), with a projected maximum of 1046 (1.5 mgd). Consumption of groundwater in Hancock County averages 26 mgd known pumpage versus 0.3 mgd known pumpage for Breckinridge County. No documented problems currently exist with groundwater withdrawals in either county. Because the major source of groundwater is the alluvial aquifer and recharge is predominantly from the Ohio River, municipal and industrial groundwater supplies apparently exceed withdrawals and will continue to do so in both counties. Stress, if any, will be greater on supplies in Hancock County, although none is presently identified. Location of high-capacity wells as close to the river as possible, and where hydraulic connection is good, reduces the effects of rapid water withdrawal on those groundwater systems farther inland.

Although river recharge of the alluvial aquifer will preclude impact of constructing foundations and other pavements and compacted areas on the alluvium, recharge of the bedrock aquifers in landfill loctions of both sites will be affected by deposition of cementitious waste products. Runoff will be increased and percolation of the predominately silt-loam soils will be decreased. Because the bedrock aquifers contribute little to groundwater supplies tapped in the project area, groundwater demand is not expected to be significantly affected.

4.4.1.2 Water Quality

4.4.1.2.1 Ohio River

Increased turbidity, suspended solids, and, to a lesser extent, increased dissolved solids will be the primary impacts of the project on the Ohio River water quality. Most of the site preparation and facilities construction that will produce these effects - docks, intake structures, discharge structures, near-shore buildings, etc. - will be constructed between 1984 and 1986 for use by Unit 1. Construction months during these 3 years are April through November (see Figure 1.3-11).

The barge unloading facility will disturb nearly a mile of shoreline at either site (see Figures 1.3-2 and 2.1-3) while water intake and discharge structures will disturb about 500 feet of shoreline (see Figure 1.3-7). Streambed disturbance from burying the intake pipes to a depth of at least 3 feet will extend 640 feet from the pumphouse. Streambed disturbance associated with the blowdown pipeline, primarily from stone- and riprap-strengthening, will extend about 50 feet from the shoreline. Onshore disturbances that will contribute to increases in Ohio River turbidity and suspended solids include construction of accesses to each facility from the road and installation of the pumphouse.

For an 8-month period each of the three years of near-shore and river work, organic materials, nutrients, and inorganic particles will be added to the water column, resulting in fluctuating turbidity and suspended solids during that time. Increased turbidity probably will be greater than increased suspended solids, and cumulative effects on water quality may cause temporary avoidance of the area by fish, waterfowl, and secondarily, fishermen and hunters. Impacts of water quality degradation on aquatic biota, wildlife, and recreation are expected to be minor and short-term. Turbidity already is high in the river, aquatic biota are predominantly pollution-tolerant species, game fish are relatively few and uncommon, and recreational fishing and hunting are more intensive on tributaries and backwaters.

Operation of the barge facilities is expected to contribute to silt load of the river downstream from the facility by resuspending silt from the river deposits and causing some instream erosion. Barge movement and unloading operations will disturb the steambed, and barge and towboat movement will create a turbulence that will tend to prevent silt deposition around the moorings. Additions to the constantly high sediment load of the river will be comparatively small, although for the life of the project.

During operation of the generating station there also is a potential for spills in the dock unloading area, with impacts on water quality variable, depending on the substances. Coal and limestone will increase suspended solids, which, like the river work effects, could have greatest impact on downstream municipalities using river water for domestic supply. The impact would be increased cost for water treatment prior to use. However, the nearest such user is Evansville, Indiana, approximately 70 miles downstream, and suspended solids from spills should be greatly reduced at that point and there should be no increase in water treatment.

Spills of oil or other chemicals could have greater impact, although the Applicant will minimize the possibility of such accidents and impacts, as described in its Oil Spill Prevention and Countermeasure Plan. This plan includes oil handling procedures, spillage procedures, and spillage reporting procedures.

Plant discharge rate to the river will be 3.7 cfs at maximum capacity. Design of the discharge structure will assure that dilution of the plant effluent by a factor of 100 to 1 will occur within 100 feet downstream of the discharge point (see Figure 1.3-15). The mixing zone is needed to dilute arsenic, fluoride, barium, sulfate, selenium, and chloride below drinking water or aquatic life standards (see Table 1.3-10). Iron, mercury, cadmium, phenol, chromium, lead, manganese, and cyanide are above one or more Kentucky standards in river water and cannot be diluted with a mixing zone. All parameters will meet 44% LC_{50} values at the point where the discharge velocity is 2 feet per second. Dilution of parameters exceeding drinking water standards will be assured at the nearest withdrawal point more than 70 miles downriver.

Heat discharged to the river, which is a function of time of year and load factor, will vary. Discharge temperature will average 82°F in summer and 64°F during winter. Maximum discharge temperature is expected to be 96°F in summer and 69°F in winter. At maximum plant capacity and greatest differential in discharge and river temperature, a 2°F surface isotherm will occur after a 100 to 1 dilution (see Figure 1.3-17).

Although the project is not expected to have appreciable impact on Ohio River water quality, there will be slight contributions to accumulations of heavy metals in sediments, acid precipitation, and fallout of trace elements.

4.4.1.2.2 Groundwater

Leaching into the groundwaters from the project is more difficult to predict than discharges to surface water because of the variety of factors that influence quantity and constituency of groundwater recharge. To assure no long-term impact to potable groundwater, a monitoring program will collect groundwater quality data from wells near each of the potentially affected areas on the site (see Subsection 1.3.2.8.6.4 and Figure 1.3-10 for program applicable to the Hancock site). These data will be submitted to the EPA and the Kentucky DNREP for evaluation relative to water quality standards that apply to domestic use of groundwater. Project-area-wide levels of iron and nitrates currently are higher than EPA's recommended levels for drinking water; both of these parameters could be affected by the project, as discussed below.

The Applicant has proposed clay liners for holding Ponds A, B, and C. Clay liners are one of four major types of liners: compacted earth liners, chemical sealants, rigid liners, and flexible synthetic liners. Of these, only synthetic liners are impermeable (FWS 1978). Clay liners usually have lower hydraulic conductivities than liners of other compacted soil types. If naturally occurring clays are not available, montmorillonites, especially bentonites, can be purchased and mixed with the natural soils prior to compacting into a liner. Hydraulic conductivities reported for a clay-soil mixture are 1.8 to 0.6 feet per day. According to the Applicant, clay liners for the Hancock ponds will have permeability of approximately 0.003 feet per day. Unlike rigid liners (e.g., concrete, gunite, asphalt concrete), clay and other compacted earth liners are flexible enough to withstand seismic activity sub-surface settlement, and remain stable in wet and dry conditions. Flexible synthetic liners also generally will withstand these conditions and prevent infiltration as well; although, as indicated, preclusion of leaching in this case probably is not necessary to prevent significant impact. Flexible synthetic liners are vulnerable to puncture (especially during installation), aging with exposure to sun or temperature extremes (generally conditionally guaranteed for 20 years), reaction with ponded wastes, and stresses from trapped gases or groundwater. Chemical sealants, which reduce permeability of the natural soils, are not always effective in their present state of technology.

Soil characteristics in many of the proposed landfill areas on the sites indicate relatively high permeability and potential for infiltration of trace elements and other substances in those areas. The stabilized waste to be deposited on the soils in the landfill areas is lower in both leachability and permeability than sludges, so that impacts to groundwater quality probably will be minimized.

Because few coal-fired power plants use the new stabilized waste treatment system proposed for the Hancock plant, data on potential impact on water quality characteristics are limited. Table 4.4-1 shows water quality parameters measured in surface runoff from stabilized waste areas associated with Big Rivers Electric Corporation's Reid (Green) Generating Station Units 4 and 5. The runoff was ponded and filtered (as proposed for the Hancock plant) prior to being sampled, so that the analyses are more appropriate for

Table 4.4-1. Water Quality of Ponded and Filtered Runoff from Stabilized Waste, Reid (Green) Generating Station Units 4 and 5, 1980

		Sampling Date (1980)											1981			
Parameter	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Dec	Jan	Feb	Mar	United States Drinking Water Standard (mg/ℓ)
Flow																
Average	gpd	2200	1260	1260	1440	1170	1080	1560	4060	1980	1350	720	360	1100	700	
Maximum	gpd	2880	1440	2880	1440	1440	1440	2160	14400	3600	-	1440	1400	1400	1400	
TSS																
Maximum	mg/ℓ	40	39	46	30	–	41	26	34	41	-	23	-	60	42	–
Minimum	mg/ℓ	14	4	15	2	14	3	12	10	16	-	20	-	29	35	–
Average	mg/ℓ	27	22	27	17	25	23	19	23	25	52	22	56	44	38	–
SS	mℓ/ℓ	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	–
Turbidity																
Maximum	JTU	–	7	7	–	–	–	9	9	15	17	7	-	-	15	–
Minimum	JTU	1.2	2	5	–	–	–	8	2	6	4	4	-	-	11	–
Average	JTU	–	5	7	–	–	–	9	6	11	7	2	12	-	13	–
pH																
Maximum	Standard units	–	8.5	8.2	7.7	7.9	7.8	7.6	7.5	7.8	9.0	8.0	-	8.0	7.5	5-9
Minimum	Standard units	7	7.1	7.3	7.2	7.4	7.1	7.5	7.0	6.8	6.6	7.7	-	6.9	7.3	
Average	Standard units	–	7.8	7.6	7.5	7.7	7.3	7.5	7.2	7.7	7.7	7.9	7.2	7.4	7.4	
Calcium	mg/ℓ	82	119	82	74	119	116	185	560	600	1040	473	530	729	600	–
Chloride	mg/ℓ	294	350	378	300	375	232	208	2234	1480	1418	171	2756	818	1028	250
Magnesium	mg/ℓ	13	23	20	16	38	27	82	260	255	230	490	255	530	75	–
Sodium	mg/ℓ	252	186	3	161	245	194	170	650	610	528	223	107	415	410	–
Sulfate	mg/ℓ	252	232	245	98	194	230	420	1000	770	228	178	1140	1420	1340	250
Total alkalinity	mg/ℓ	–	94	144	111	180	160	252	300	280	236	117	610	66	72	400
Total hardness	mg/ℓ	–	634	700	216	300	100	790	2762	2502	1691	1250	2502	2222	1861	–
Total dissolved solids	mg/ℓ	–	2524	860	756	924	860	1347	6742	6010	4480	1995	6078	4092	3644	750
Total solids	mg/ℓ	–	2642	940	884	980	916	1382	6772	5272	5386	2020	7292	4212	3952	–
Aluminum	mg/ℓ	2.1	0.2	0.7	1.4	1.2	5.3	1.0	0.6	0.3	0.4	0.5	<0.2	1.0	0.4	–
Arsenic	mg/ℓ	<0.001	<0.001	0.002	0.001	<0.001	<0.001	0.002	0.21	<0.001	<0.001	<0.001	<0.001	<0.001	0.10	0.05
Chromium	mg/ℓ	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.06	<0.01	0.26	0.05	0.05
Copper	mg/ℓ	<0.01	0.02	0.02	0.02	0.01	<0.01	0.02	0.09	<0.05	0.02	0.02	0.06	0.05	0.04	1.0
Iron	mg/ℓ	1.5	0.2	0.5	1.02	1.0	1.0	0.8	0.43	0.4	0.26	0.45	0.25	0.09	0.27	0.3
Lead	mg/ℓ	0.009	<0.001	<0.001	0.006	<0.001	0.008	0.003	0.02	<0.001	0.004	0.006	0.008	0.009	0.002	0.05
Manganese	mg/ℓ	0.46	0.12	0.3	0.23	0.47	0.55	0.66	2.24	2.70	3.10	0.30	10.1	1.27	2.08	0.05
Mercury	mg/ℓ	<0.001	<0.001	<0.0002	<0.0002	<0.001	<0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.002
Nickel	mg/ℓ	<0.1	<0.1	<0.1	<0.1	0.05	<0.05	<0.1	0.09	0.2	0.1	0.05	0.10	0.11	0.10	–
Selenium	mg/ℓ	0.01	0.01	0.001	0.01	0.01	0.01	0.01	0.01	0.01	<0.01	<0.010	<0.010	<0.010	0.03	0.01
Zinc	mg/ℓ	0.04	0.05	0.1	0.04	0.08	0.03	0.05	0.74	0.71	0.47	0.03	0.26	0.07	0.08	5.0

*Apparent error in data reporting since total solids should be greater than total dissolved solids.

Source: EPA Region IV (1980).

characterizing water quality effects on onsite streams than for estimating effects on groundwater. However, several potential leachates can be identified, assuming similar stabilized wastes. The Hancock plant will produce a mixture of cementitious sulfites and sulfates, while the Reid plant apparently produces primarily cementitious sulfites, which are less permeable than sulfates in sludges (FWS 1978). Other variables would be composition of fly ash and bottom ash, although for the most part, variability should not be significant. There are no baseline water quality data from the bedrock aquifers of the landfill areas comparable to those shown in Table 3.4-22 for the alluvial aquifer at the Hancock site.

Depending on permeability of soils, among other factors, the Reid Station data indicate significant increases could occur in hardness and total dissolved solids of groundwater. Existing hardness of groundwater from the Hancock site was not measured but values as high as those recorded from landfill runoff at the Reid Station (very hard category, EPA 1976) would be rare in groundwater of the sandstone aquifers, which are the more important of the bedrock aquifers in the project area and in proposed landfill locations. Hardness per se has no health or welfare effects but may become a matter of economics should treatment be necessary prior to use (EPA 1976). Total dissolved solids may have some welfare and health effects in large quantities. Good tasting water generally contains less than 750 mg TDS/liter, as reported for sandstone aquifers in the project area (Maxwell and Devaul 1962). Sulfate and chloride contents of total dissolved solids, which may produce adverse effects in susceptible persons, were above drinking water standards in several samples from the Reid Station treated runoff. Trace inorganics that often exhibited higher levels than drinking water standards were manganese and iron. As mentioned above, the effects of excess manganese and iron on human health are basically unknown, although excess iron may affect the taste and use of water and have toxic effects on aquatic life. Manganese and especially iron leachates would contribute to already high levels. Although nitrates were not tested in the Reid Station runoff and may not be a significant constituent of either runoff, fertilizer application during revegetation of landfill areas could increase already high levels.

Selenium was higher than drinking water standards on one occasion (March 1981). It is doubtful that sufficient selenium would be leached into groundwater to allow the possibility of ingestion of toxic amounts (greater than 0.1 mg per day), although this would depend on ambient concentrations. It is assumed that groundwater monitoring will detect any impact on ambient levels.

4.4.1.3 Aquatic Biota of the Ohio River

Increases in turbidity and suspended materials generally interfere with the respiration of aquatic organisms. Such impacts to fish, planktonic, and benthic communities are expected to be localized and short-term but possibly severe. Adult fish may be excluded from an area of the river a short distance downstream from the plant site as a result of turbidity during construction activities. The greatest impact to fish from increased turbidity and installation activities will occur during the spawning months (April to June) and when fish larvae are most dense (June). Planktonic and benthic organisms in the immediate vicinity will be severly stressed and some benthic species may be eliminated. The impact on river populations will probably be quite limited, as the species present are adapted to high turbidity.

Placement of barge facilities and intake and discharge structures will mean the elimination of a limited area of aquatic bottom habitat (mainly for mollusks and other benthic organisms), while creating structure for fish and possibly certain benthic organisms. Barge traffic (docking) will cause continuous disturbance of bottom sediments for the life of the power plant, creating greater stresses on the benthic community in the immediate vicinity of the dock.

Intake of cooling water makeup will impinge and entrain some aquatic organisms, mainly fish eggs, fish larvae, planktonic algae and zooplankton. In conjunction with issuance of the NPDES permit and subsequent approval to begin operation of the proposed power plant under the permit, EPA must evaluate the adverse impact of cooling water intake structures on the aquatic environment. The provision for this evaluation is Section 316(b) of the Clean Water Act of 1977, which requires that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse impacts. EPA tentatively has determined that the requirements of Section 316b are met by the proposed intake. Alternative intake systems were discussed in Subsection 2.1.4.4.

Location. Proposed locations of the intake and discharge structures are RM 716 at the Hancock site and RM 705.5 at the Breckinridge site. The two intake pipes will extend into the river 340 and 640 feet, respectively. Depth of the intake screens will be 22 feet. One year's data on aquatic populations were collected upstream and downstream of intake positions at each site. At the Hancock site, one year's data showed greater numbers of fish, fish eggs and larvae, and macrozooplankton were collected upstream from RM 716, and at the Breckinridge site, greater numbers of the same groups were collected from RM 705 than from RM 707. Distribution data for fish eggs and larvae at both sites showed no consistent trends across the river nor with depth. Species composition of each group of organisms was similar at all sampling locations, with commercial, game, and rare fish in low numbers. Threatened or endangered species are not a factor, although declined mussel populations are. No significant mussel beds were found at any sampling location so there should be no impact on these bottom fauna.

Location of the intake and discharge structures at RM 716 at the Hancock site and at 705.5 at the Breckinridge site shortens length of the piping to the cooling towers to the extent possible. The discharge pipe extends 38 feet into the river at a depth of 6 feet and is somewhat downstream of the intake structures. These distances between intake structure and the discharge outfall should be sufficient to preclude recirculation of the discharge water and impingement and entrainment of aquatic life that may aggregate in the thermal plume of the outfall. Depth of the intake structures will be more than twice the 9-foot channel depth maintained by the COE.

Design. Designs of the intake structures and discharge structure should meet guidelines that provide for environmental and cost considerations. As discussed in Subsection 2.1.4.4, construction, maintenance, entrainment, impingement, and cost were considerations in the selection of intake structures. The offshore stationary slotted screen intake structures that are proposed will have intake velocities of 0.5 feet per second or less, as suggested by EPA. They will be oriented and shaped such that resistance to natural water flow is minimal. They are expected to be self-cleaning and to have less impingement and entrainment effects than onshore traveling screens. The intake pumps will be housed on the shoreline, so that their motors will be above design high water level.

Construction. Construction specifications of the intake and discharge structures are shown in Figure 1.3-7. Many of the effects of construction on aquatic life were discussed in the preceding subsection. Others were discussed above. As noted, construction impacts overall will be minor and short-term since dredging maintenance is not anticipated. They are expected to be of similar magnitude to those associated with construction of onshore traveling screen systems, which generally require periodic dredging to remove silt build-up in front of the screens.

The construction schedule of April through November (during three successive years) would have less impact on fish populations if dredging were omitted when fish larvae are most dense.

Capacity. Intake volume is minimized by the use of cooling towers and the circulating water system described in Subsection 1.3.2.8.6.1. Since entrainment and impingement of aquatic life also are functions of intake volume, minimal makeup requirements will reflect minimization of impact.

Assuming even distribution of fish eggs and larvae and other planktonic components (as indicated by sampling results), entrainment expected at the plant may be estimated as the percent of river flow represented by makeup flow. As shown in Section 4.4.1.1.1, maximum entrainment, estimated as percent of the 7-day, 10-year low flow, would be 0.26% of the river's planktonic populations. Average entrainment for 7Q10 conditions would be 0.15%. Under average river conditions (approximately 150 thousand cfs) and maximum plant load, entrainment would be about 0.02%. This would be expected in July and August, when fish eggs and larvae density has declined from the June peak.

4.4.2 Hancock Site Alternative

4.4.2.1 Generating Station

4.4.2.1.1 Ohio River

Navigation. The Louisville District COE has determined that KU's barge docking and fleeting facility, as now proposed at the Hancock site, has a significant projection into the Ohio River and will present a moderate hazard to navigation. Construction of the barge docking facilities will vary from somewhat more than 600 feet (downstream end) to 370 feet (upstream end) inland from the existing river channel (see Figure 1.3-4). With docked barges, the outer barge will reduce the facility-to-sailing line distance to 265 feet at the upstream end. Construction of the intake structures will be 450 feet away from the navigation channel and deep enough to withdraw water during minimum low flow (lock and dam failure), so that they will present no navigation hazard.

Additional potential hazard to navigation is the chance of barge breakaway at the docking facilities. The Applicant will reduce the potential for breakaway by having a tow boat at the site when barges are docked there.

During the DA permit review, KU provided the COE with 14 potential fossil-fuel power plant sites for evaluation of navigation impact. These potential sites included the nine preferred sites and five others identified during the site selection study described in Section 2.1.3. The COE rated each site on a scale of 1 to 5, where 1 = no impact, 3 = moderate impact, and 5 = extreme impact. The Hancock site (Ohio RM 715) received a 5 rating and the Breckinridge site (Ohio RM 704) received a 4 rating. The best rating received by a site having potential navigation impact was 2. Among the preferred sites, L-17 and L-8, which would require fuel delivery by rail, were given a 1 rating. Among the other preferred sites, 0-22 received a 5 rating, G-1, 0-8, and 0-11 were given 3 ratings, and 0-12 received a 2 rating.

Water Quality. The potential difference between Ohio River water quality impacts of the Hancock site alternative and the Breckinridge site alternative is synergistic effects due to discharge of the Willamette Industries paper plant adjacent to the Hancock site. This potential is minimized by both the distance of the paper plant discharge from that of the Hancock plant discharge (4 miles) and the prospect of little chemical reaction between an effluent dominated by organic materials (paper plant) and one dominated by inorganic materials (power plant).

The paper plant discharge, which is located downstream, averages 5.8 mgd compared with an average of 1.5 mgd projected for the Hancock plant. The paper plant is permitted to discharge an average of 6452 mg/l total suspended solids and actually averages nearer 5000 mg/l. KU's projected suspended solids load in its blowdown water is 400 mg/l, so that only a minor incremental effect on TSS at the point of the paper company discharge could be attributable to the generating station. The pH values of the paper company discharge generally are 7.0 to 7.5, and pH values of the Hancock plant are expected to be in the same range. The only apparent chemical reacton or synergism that could be detrimental to water quality (production of halogenated hydrocarbons) might occur as a result of chlorine from KU's discharge reacting with organics in the paper company discharge. However, this is a most unlikely occurrence because of the distance the effluent travels before being mixed and the highly reactive nature of residual chlorine.

Discharges to onsite streams from the Hancock project will enter the Ohio River downstream from and nearer the paper plant discharge. These discharges also will have no chemical wastes that would react with the paper plant effluent, but are projected to have about 50 mg/l TSS during plant operation. Current TSS is highest in Indian Creek (maximum recorded value = 149 mg/l) (see Table 3.4-17), which will be least affected by construction activities that are expected to temporarily increase suspended particle discharge above projections for the operation phase. Projected TSS concentrations in discharge added to ambient concentrations in onsite streams will rarely exceed 100 mg/l, which will be a minor increment to TSS effects from the paper plant.

Aquatic Biota. Water quality effects on aquatic biota of the Ohio River from the Hancock project are projected to be similar at each site. Because of the similarity in benthic communities especially, the impact of installation of dock facilities and other structures in the river, is expected to be approximately the same at each site. The foremost difference in impacts to aquatic biota of the river at the two sites is in entrainment potential. Collection data from five locations on the river showed June and July 1979 fish eggs and larvae density to be highest at RM 715 at the Hancock site and one collection from June 1980 showed the same. Further, except during June when collections at both locations at the Breckinridge site (RM 705 and 707) showed higher densities than the two other locations near the Hancock site (RM 717 and 722), densities were consistently higher at the Hancock site locations. This indicates greater entrainment of fish eggs and larvae by an intake at the Hancock site, but no significant impact is anticipated based on the small percent of the populations expected to be entrained.

4.4.2.1.2 Groundwater

Considerable groundwater is currently being withdrawn at the Hancock site in association with the paper industry. Additional withdrawals by the Applicant could lower the alluvial aquifer water table, although because of rapid recharge from the Ohio River significant water table lowering is not anticipated.

The potential impacts to groundwater quality discussed in Subsection 4.4.1.2.2 should occur primarily in landfill areas on the sites since liners are proposed for holding ponds. Impacts on groundwater use from these effects are unknown because recharge patterns in the bedrock aquifers are uncertain. Industrial users in the vicinity of the Hancock site should not be affected because they are tapping the alluvial aquifer.

4.4.2.1.3 Onsite Streams

Water Quantity and Water Quality. Site runoff is expected to increase during all phases of project life because of land-clearing activities, but its discharge to streams will be greatest during the construction phase, especially prior to construction of the site runoff retention basin. The site runoff retention basin and those associated with coal and limestone storage areas and landfill areas will serve to collect water and allow substantial sedimentation prior to release to streams. Discharged water will be filtered at the release point. Sandy Branch, which will receive site runoff as well as drainage from a landfill area, will have the most water quality impacts related to increased runoff turbidity. The impacts are expected to be minor because of erosion and runoff controls that will be implemented.

As mentioned in the discussion of characteristics of runoff from stabilized waste at another power plant (Subsection 4.4.1.2.2; Table 4.4-1), precise application of these data to conditions at the Hancock site are precluded because of several variables that influcence such characteristics. Assuming runoff similar to that described for the Reid Station, total dissolved solids and chloride and sulfate fractions would increase significantly in the receiving stream during landfill activities. Iron and manganese also would increase. The streams do not provide drinking water, so that effects pertain to aquatic life only. Total dissolved solids levels up to 10,000 mg/liter have little known effect on aquatic biota (EPA 1976), so that increases up to 2000 mg/liter are expected to have no impact. Excess iron, although lethal to several species, is not expected to impact aquatic biota on the site since they are adapted to existing excess iron. The effects of manganese, if any, are virtually unknown, as mentioned previously. Because detection limits of mercury in samples from the Reid Stration were above the Kentucky's aquatic life standard (0.00005 mg/liter), the potential for adverse effects on this trace element on stream organisms cannot be predicted.

It is expected that discharges from the streams into the Ohio River will be sufficiently diluted at the nearest municipal user (Evansville, Indiana, 70 miles downstream) to have no impact on drinking water quality.

Aquatic Biota. Existing habitats associated with the onsite streams will be irreversibly altered by vegetation removal, channelization, and damming. The increase in turbidity and potential for more rapid runoff may further alter the stream habitat and, therefore, the biological communities. Deposition of sediment and increased suspended solids may adversely affect the benthic and fish fauna during the construction phase. However, the shifting sand substrates and low flows of the streams, along with existing erosional and nutrient problems from agricultural activities, have led to a relatively poor and pollution-tolerant faunal assemblage. Nevertheless, diversity of fish and other faunal communities, especially benthic assemblages, may be expected to decrease in the more uniform stream environment. Drift components that add to the Ohio River fauna also may be expected to diminish in diversity. This probably will have no significant impact on Ohio River benthic populations because of apparently small contributions from the streams. Local populations of the pirate perch, which is in danger of extinction in Kentucky, could be affected by the displacement of its known onsite habitat, Sandy Branch, although habitat requirements and Kentucky distribution indicate the species could exist in Muddy Branch and Indian Creek as well.

4.4.2.2 Transmission System

Unit 1. The southward right-of-way from the site will cross Indian Creek, Honey Locust Creek, and Sugarcamp Branch. All of these will be spanned and no construction will occur instream (Figure 4.4-1). Construction impacts to these streams will include increased total dissolved and suspended solids and slightly increased runoff with any rainfall event. The construction of this right-of-way during 1988 will have minor impacts on the overall water quality and aquatic organisms present.

Because these streams are in mixed areas of agriculture, forest, and pasture land, they are subject to periodic increases in sediment, turbidity, and dissolved solids. The increased erosion will cause additional siltation, possibly with the temporary loss of some organisms (specifically aquatic insects) from certain stretches. Because construction will be of short duration, little lasting impact is anticipated.

During operation of the power plant maintenance of the right-of-way will consist of hand clearing in sensitive areas with approved herbicides applied on the remainder. Some drift of herbicide could occur with the proposed aerial application and there may be subsequent damage to areas outside the right-of-way.

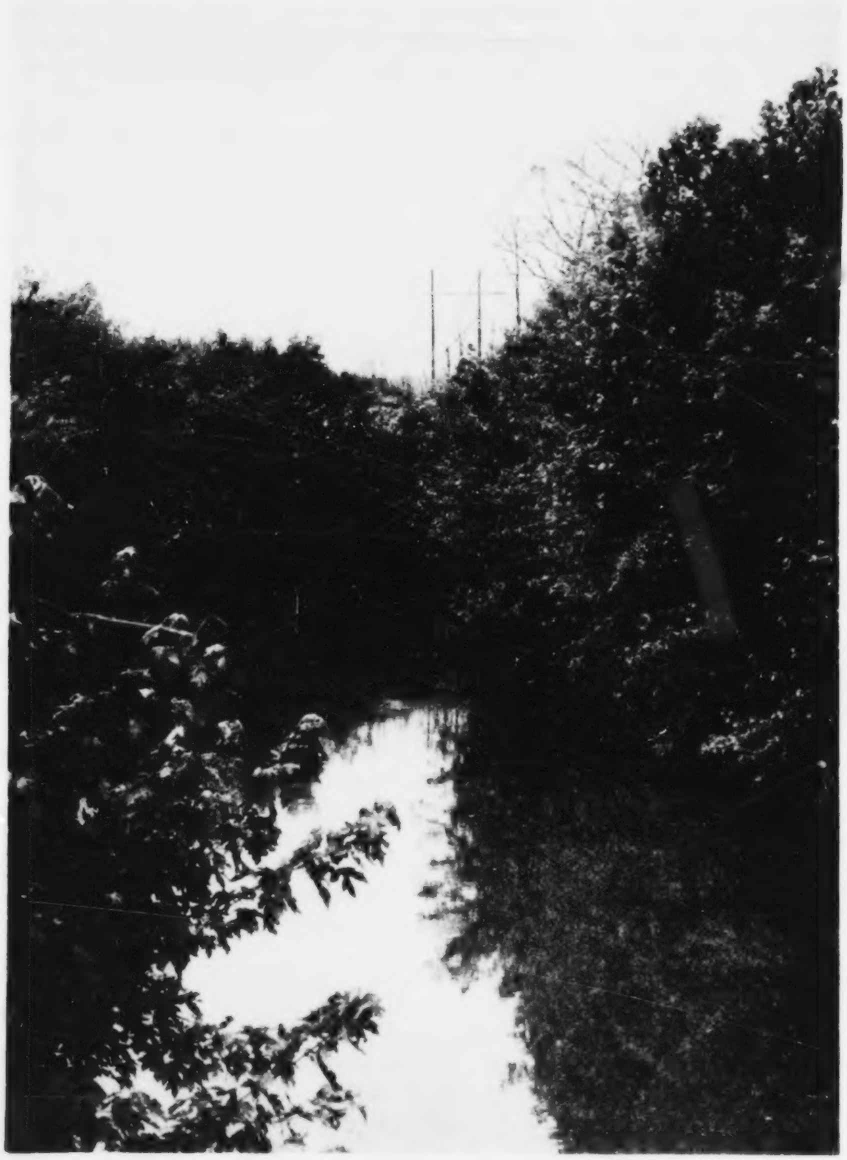


Figure 4.4-1. Stream Crossing, Elizabethtown Transmission Corridor, 1980

Unit 2. The Unit 2 right-of-way to be constructed adjacent to the existing right-of-way to Elizabethtown will cross a number of water bodies (see Table 3.4-27). Impacts to these will be similar in kind but smaller in degree than described for the Unit 1 right-of-way. Because of the potential difficulty in spanning without disturbing vegetation, greatest effects likely will be in the area between the Hancock north-south corridor and the Breckinridge north-south corridor. Another crossing of potential difficulty is the Hicks Lake wetland area near Franklin Crossroads between Howe Valley and Cecilia. This appears to be the most ecologically sensitive water body to be crossed (see Sheet 7 of Figure 3.1-18).

4.4.3 Breckinridge Site Alternative

4.4.3.1 Generating Station

4.4.3.1.1 Ohio River

Navigation. Specific docking facility design has not been proposed for the Breckinridge site. However, the COE's evaluation of navigation impact of alternate sites indicated that the Breckinridge site was in the significant impact category, just below the extreme impact category that includes the Hancock site (see Subsection 4.4.2.1.1).

Water Quality. There presently are no discharges to the Ohio River in proximity to the proposed discharge point (RM 705) at the Breckinridge site. However, discharge, if any, from the proposed H-Coal facility would be within 2 miles downstream. Effluents in the synfuel discharge may be expected to be somewhat different from those in the power plant discharge. Possible chemical reactions or synergistic effects between these discharges would have to be evaluated when potential effluent concentrations of the synfuel facility are known.

Aquatic Biota. Impacts on the Ohio River at the Breckinridge site are generally similar to those described for the Hancock site. Fish and macrozooplankton populations are generally similar in the river at the sites; however, consistently lower numbers of fish eggs and larvae were collected from the Ohio adjacent to the Breckinridge site during the 1979-80 study (see Tables 3.4-14 and 3.4-24). No notable differences were observed in benthic fauna and the amount of substrate disturbed would be similar at both locations.

4.4.3.1.2 Groundwater

The power plant alone will have no impact on groundwater quantity on the Breckinridge site. Combined withdrawals of the power plant and H-Coal facility could lower the alluvial water table, although as at the Hancock site, rapid recharge from the Ohio River should preclude significant impact.

4.4.3.1.3 Onsite Streams

Water Quantity and Water Quality. Present water quality of upper Town Creek (the only stream on the site) is better than that of lower Town Creek and streams on the Hancock site, and overall impacts of channelization, suspended sediment, and runoff will be greater. Like Sandy Branch on the Hancock site, upper Town Creek will lose its present character and become a discharge structure for site runoff. The effects on Town Creek from landfill operations will be similar to those described for the Hancock streams. There should be minimal impact on lower Town Creek and the embayment from TSS levels if they are maintained at 50 mg/liter or less.

Aquatic Biota. The pollution intolerant species occurring in upper Town Creek will be displaced. The impact in this respect would be greater than the impact occurring to the stream biota on the Hancock site. Little or no impact is anticipated to lower Town Creek as it is already turbid with runoff from associated agricultural lands.

4.4.3.2 Transmission System

Unit 1. Streams crossed by the Breckinridge Unit 1 transmission corridor are Town Creek, Bull Creek, Clover Creek, Little Beach Fork of Clover Creek, and Hites Run. As with the Unit 1 corridor for the Hancock site, erosional products, suspended solids, turbidity, and dissolved solids will increase with clearing of the right-of-way. Herbicide application for right-of-way maintenance will be performed with very low levels of these materials entering the streams. Because of the longer corridor (3 to 5 miles) and greater number of streams, overall impact associated with the Breckinridge Unit 1 corridor will be greater than that for the Hancock Unit 1 corridor. The magnitude of impact to any single stream or stream segment will be similar for each site. Overall impacts to aquatic organisms and water quality may be severe but of short duration. Overall impacts to these waters should be relatively small.

Unit 2. Impacts of constructing an additional transmission line along this corridor will be similar to those above for Unit 1 and for Unit 2 of the Hancock site. The major exception is that this right-of-way will be shorter than that required for Hancock Unit 2, eliminating the need to recross the Tar Fork of Clover Creek and another tributary to Clover Creek. This decreased distance along the existing corridor represents a small reduction in overall impact compared with that associated with the Hancock Unit 2 line.

4.5 ENVIRONMENTAL CONCERNS

This section addresses those environmental elements, other than air and water quality, that have been identified by Federal or other agencies for special management procedures. Most of these elements have been mentioned in preceding sections. Their status in the Hancock project area is summarized in this section, and laws, regulations, or other directives applicable to each element are cited.

4.5.1 Historic and Archaeological Resources

National Historic Preservation Act of 1966 (16 U.S.C. 470 et seq.)
Archaeological and Historic Preservation Act of 1974 (16 U.S.C. 469 et seq.)
Protection and Enhancement of the Cultural Environment (Executive Order 11593)

The National Historic Preservation Act protects historic and cultural properties that are eligible for or on the National Register of Historic Places. It established the Advisory Council on Historic Preservation and requires that Federal agencies involved in Federal, Federally assisted, or Federally licensed actions afford the Council an opportunity to comment on actions that affect properties included in or eligible for inclusion in the National Register of Historic Places. The Archaeological and Historic Preservation Act authorizes the Secretary of the Interior or designee to undertake data recovery or preservation activities if an action may cause irreparable loss of significant paleontological, historic, or archaeological data. Executive Order 11593 directs Federal agencies, in consultation with the Advisory Council, to institute procedures to assure their plans and programs contribute to the preservation and enhancement of nonfederally owned historic and cultural properties. Regulations implementing the National Historic Preservation Act (36 CFR 800) require Federal agencies to consult with State Historic Preservation Officers (SHPO) to determine effects that an action may have on historic and cultural properties. Accordingly, EPA Region IV consulted with State Historic Preservation Officers of Indiana and Kentucky to determine the status of standing structures and archaeological sites in the project area.

Archaeological and historical resources are nonrenewable. The impacts of disturbing archaeological and historical resources range from direct destruction of specific sites to changes in the integrity of the setting or feeling of the property that contributes to its significance (36 CFR 800). Other possible adverse effects include isolation of the site from the surrounding environment; introduction of out of character visual, audible, or atmospheric elements; neglect; or transfer or sale of the property without adequate preservation restrictions.

Each of the cultural sites of the developed areas will be indirectly affected by land modification activities: the predominately rural character of the plant site area will be changed to an industrial setting, and the presence of transmission lines in rural areas will create an out of character visual element. Construction of buildings, roads, pipelines and docks on the plant site will disturb archaeological and historic sites on lowland areas and along the Ohio River, while landfills will alter those sites in uplands. Because of extensive preconstruction evaluation and salvage and mitigation during construction, if warranted, loss of undiscovered sites is not expected.

Numbers of significant archaeological sites and historical standing structures within view of or on either the Hancock or Breckinridge site are:

Hancock Site

Indiana side of Ohio River: 3 standing structures were determined by the Indiana SHPO to be eligible for nomination to the National Register. It was further determined that the Hancock project would have no adverse impact on these structures.

Hancock site: 33 archaeological sites identified on the Hancock site were recommended by the Kentucky SHPO for testing to determine eligibility for nomination to the National Register. 5 of these sites are now believed outside the site boundaries.

No standing structures surveyed on the Hancock site were determined by the Kentucky SHPO to be eligible for nomination to the National Register.

7 historic cemeteries occur on the Hancock site.

Breckinridge Site*

Indiana side of Ohio River: 1 standing structure was determined by the Indiana SHPO to be eligible for the National Register.

Breckinridge site: 5 archaeological sites identified on the Breckinridge site were recommended by the Kentucky SHPO for testing to determine eligibility for nomination to the National Register.

2 standing structures on the Breckinridge site are on the National Register: the Holt House and the Holt Chapel. The Holt House will not be directly affected by construction activities but will be subject to impacts from increased noise, traffic, and fugitive dust. The Holt Chapel is in a location that will be part of the plant facility complex.

No standing structures surveyed on the Breckinridge site were determined by the Kentucky SHPO to be elibgible for nomination to the National Register.

3 historic cemeteries occur on the Breckinridge site.

*The archaeological survey of the Breckinridge site was only 65% complete, so that other significant archaeological sites may be present. Because that part of the site yet to be surveyed is in uplands rather than lowland areas near the river, it is believed that few, if any, additional significant sites will be identified.

One standing structure along the Elizabethtown Corridor was determined by the Kentucky SHPO to be eligible for nomination to the National Register. It will be affected by construction of the Unit 2 transmission line from either site. The aesthetic impact on its viewshed will be intensified for the long term by the addition of the new line, and it will be subjected to increased fugitive dust, traffic, and noise during short-term construction activities.

4.5.2 Prime Farmland

Although not protected by Federal law except on lands proposed for surface mining (Public Law 95-87), prime and unique farmlands are addressed by USDA Soil Conservation Service policy (7 CFR 657). SCS has expressed concern about any action that tends to impair the productive capacity of American agriculture and has set policy to make and keep current an inventory of prime farmland and unique farmland, in cooperation with state and local agencies. SCS personnel, specifically the State Conservationists, are to provide leadership for inventories of important farmlands for the state, county, or other entity, and prepare a statewide list of soil mapping units that meet the criteria for prime farmland (as identified in 7 CFR 657).

The SCS State Conservationist for the Commonwealth of Kentucky issued a preliminary listing of Prime Farmland Soils of Kentucky in May 1979 (Kentucky Invent. & Monit. Bulletin No. KY 42-9-4). The list, which will be finalized following coordination with other states, as provided for in SCS policy, contains some soil types that must meet specified flooding and/or drainage criteria to qualify as prime farmland. According to SCS policy, onsite surveys may be necessary for official determination of the status of these soil types. Basically, candidate soils for prime farmland status are those that have productive qualities and occupy relatively level terrain.

Prime farmland soils occurring on the project site will be destroyed by construction and landfill activities.

Hancock Site. A comparison of the Kentucky prime farmland soil types with those surveyed and mapped for the Hancock site (SCS 1974) revealed that 21 of 40 map units are prime farmland soil types. Most of the 21 soil types, some limited in extent, must be field-checked to determine status as prime farmland (Kentucky DNREP' Personal Communication 1980). Altogether, possible and known prime farmland comprises about 45%, or 1050 acres, of the site.

Breckinridge Site. A comparison of the Kentucky prime farmland soil types with those preliminarily identified on the Breckinridge site (Breckinridge County SCS, personal communication 1980) revealed that 21 of 42 known map units are prime farmland soil types. Most of these also must meet flooding and/or drainage criteria for a determination of prime farmland. Altogether, identified possible and known prime farmland comprises about 45%, or 1125 acres, of the site. The SCS survey has not been finalized on about 20% of the site, so that extents of known and possible prime farmland cannot be estimated.

4.5.3 Wetlands

Protection of Wetlands (Executive Order 11990)

Like the Executive Order pertaining to the protection and enhancement of the cultural environment, this and similar orders were issued in furtherance of the National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.). Executive Order 11990 requires Federal agencies conducting activities and programs affecting land use, including but not limited to water and related land resouces planning, regulating, and licensing activities, to avoid, to the extent possible, adverse impacts associated with the destruction or loss of wetlands. It further requires Federal agencies to avoid support of new construction in wetlands if a practicable alternative exists. Wetlands as defined by the Order generally include swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, river overflows, mud flats, and natural ponds.

Hancock Site. Wetlands inventoried by the Kentucky Department of Fish and Wildlife that are associated with the Hancock site are Indian Lake and a small lake near Muddy Branch. Both are Type 5 wetlands which are inland open fresh water (U.S. Fish and Wildlife Service 1979). A wetland that has not been inventoried by Kentucky lies inside the northern boundary of the site. This is a shallow marsh that ranges in extent from approximately 4 acres during spring to about 1 acre during summer. The existing hydrological regime in all of these locations will be altered by project control over natural drainage patterns and runoff.

Breckinridge Site. The Breckinridge site is associated with one wetland embayment inventoried by the Kentucky Department of Fish and Wildlife: Town Creek Embayment. In its study of the natural, historical, and recreational resources of the Ohio River Basin, the Ohio River Basin Commission (1978) recommended that the Town Creek Embayment be investigated within 1 to 5 years to determine applicability of the area as a Commission project for conservation. It will be affected by alteration of natural drainage patterns and runoff.

4.5.4 Floodplains

Floodplain Management (Executive Order 11988)

Executive Order 11988 was issued in furtherance of the National Flood Insurance Act of 1968 (42 U.S.C. 4001 et seq.) and the Flood Disaster Protection Act of 1973 (Public Law 93-234, 87 Stat. 975) as well as NEPA. In addition to directing Federal agencies to reduce the risk of flood loss and minimize impact of floods on human safety, the order also requires that Federal agencies evaluate the effects of actions they may take in a floodplain to avoid, to the extent possible, adverse effects on the natural and beneficial values served by floodplains. Floodplains defined by the order are, at a minimum, those areas subject to a 1% or greater chance of flooding in a given year.

Hancock Site. The 100-year floodplain elevation at the Hancock site is 406.3 feet msl. Elevation of the 1937 flood of record at the site, adjusted for recent lock and dam construciton,is 407.9 feet msl. Areas within the 100-year floodplain on the site include locations north and east of the Louisville and Nashville R.R. and locations bordering Sandy Branch (see Figure 3.1-6). The floodplain associated with Sandy Branch will be destroyed as the upper stream is channelized to accomodate site runoff. Construction of onshore berms and structures associated with the coal and limestone unloading system and the intake and discharge systems will occur in the floodplain between river miles 715 and 716.5 (1.3-2).

Breckinridge Site. At the Breckinridge site, the 100-year floodplain elevation is 412.3 feet msl. Adjusted elevation of the 1937 flood of record is 414.3 feet msl. Areas within the 100-year floodplain on the Breckinridge site include locations west of the Louisville and Nashville R.R. and locations bordering Town Creek (see Figure 3.1-7). As on the Hancock site, the floodplain along Town Creek will be destroyed as channelization and other modifications are done to accomodate site runoff and in this case, to construct landfill areas. Onshore berms and structures associated with the coal and limestone handling system and the discharge system will be constructed in the floodplain at river miles 703.5 and 705.5 (see Figure 2.1-3).

4.5.5 Fish and Wildlife Resources

Fish and Wildlife Coordination Act of 1965 (16 U.S.C. 661 et seq.)

One of the provisions of the Act requires Federal agencies involved in actions that will impound, divert, deepen, or otherwise control or modify for any purpose a natural stream or other water body to take action to protect fish and wildlife resources that may be affected. Federal agencies involved in such actions are to consult with the U.S. Fish and Wildlife Service and the appropriate Commonwealth agency to determine measures to conserve and improve wildlife resources that may be affected by the actions.

Hancock Site. The Hancock site has three streams: Indian Creek, Muddy Branch, and Sandy Branch. All have natural riparian habitat and none has been channelized. Sandy Branch, as mentioned, will lose its natural character. It is the only known habitat on the site for the pirate perch, a species that is in danger of extinction in Kentucky. Topographic changes associated with landfill operations will alter runoff patterns and headwaters of Muddy Branch and Indian Creek. Water quality changes in these streams are expected to be greater total dissolved solids, iron, and manganese. These are expected to have no impact on existing biota.

Breckinridge Site. The single stream on the Breckinridge site is Town Creek, which also has natural riparian habitat and has not been channelized, although pool elevation of the Ohio River has flooded its mouth. Town Creek will be altered significantly to form a channel for site runoff. Its headwaters will be altered as topography is changed during landfill operations. Pollution-intolerant bottom organisms will be displaced, perhaps indirectly affecting fish and wildlife resources through the food chain.

4.5.6 Threatened and Endangered Species

Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.)

The Act protects threatened or endangered plant and animal species and their critical habitat as designated by the Secretary of the Interior. Regulations implementing the Act (50 CFR 402) require Federal agencies to consult with U.S. Fish and Wildlife Service if listed species or habitat essential for their survival may be affected by Federal projects, plans, licenses, and other activities. Accordingly, EPA Region IV consulted with FWS to confirm the status of threatened and endangered species in the project area.

No threatened or endangered plants or animals listed by DOI were observed during vegetation and wildlife surveys on the Hancock and Breckinridge sites. Records of Federally listed species in western Kentucky do not include Hancock, Breckinridge, and Hardin counties (FWS, personal communication 1978; Kentucky Nature Preserves Commission 1979).

During development of this EIS program, the Kentucky Department for Natural Resources and Environmental Protection requested that species listed on the Kentucky Nature Preserves Commission's Plant and Animal Element List be addressed. These plants and animals are among the elements of natural diversity, both biological and physical, that are considered threatened with extirpation from the state if something is not done in their behalf. It is the intent of the Commission to identify, map, and monitor these elements to maintain the natural world in the diverse state in which it developed. Observations during onsite surveys of species on the Animal Element list will add records to those currently in the Commission's files.

Hancock Site. Observations indicate that the evening bat is a resident of Jeffry Cliff and associated woodlands. These locations also provide roosting sites for the black vulture. Sightings of other listed wildlife species on the site included the great blue heron the great egret, and the marsh hawk. One fish on the Commission's list, the pirate perch, was seined from Sandy Branch. Larvae of another, the paddlefish, were collected at Ohio River Mile 717. Known onsite habitat of the pirate perch probably will be destroyed, but habitat requirements and Kentucky distribution indicate Indian Creek and Muddy Branch could support the species as well. Impacts on the evening bat and black vulture are uncertain and depend upon their tolerance of activity near the cliff. No significant impacts are expected to the other species.

Breckinridge Site. Three birds on the Commission's list were sighted on or near the Breckinridge site: the black vulture, great blue heron, and great egret. Larvae of the paddlefish were collected at Ohio River Mile 707, and an adult river shiner was collected at the same location. No impacts are expected to the bird species based on observations of occasional site usage. Impacts to the fish species are expected to be slight based on minimal entrainment and impingement due to cooling water intake and discharge.

5.0 METHODOLOGY

Those aspects of the Hancock Generating Station EIS program that included primary data gathering were human population density, land use/land cover, cultural resources, vegetation, wildlife, and aquatic resources. Other primary data incorporated into the EIS were results of Sargent & Lundy subsurface investigations of soil and aquifer characteristics, results of Kentucky Utilities (KU) water quality analyses, and results of Texas Instruments ambient air quality monitoring program. The investigations for the EIS program, the engineering study, and the air quality program were conducted on both the Breckinridge and Hancock sites, while KU's water quality analyses were conducted only on the Hancock site. Specific survey locations and methodologies are described below.

All field investigations for the EIS program, except parts of the cultural resource survey, were conducted by Texas Instruments (TI). The University of Kentucky Research Foundation conducted all archaeological investigations and historic resource surveys on the Hancock and Breckinridge sites. Texas Instruments conducted historic resource surveys in the vicinity of the two sites and along the existing Elizabethtown transmission corridor. TI also conducted the survey of aesthetic resources in the project area. Evaluations of the archaeological data were performed by the University of Kentucky and the Kentucky Heritage Commission. Evaluations of the historic resource surveys were performed by Walter E. Langsam, an architectural historian, and the Kentucky and Indiana Heritage Commissions.

Field and laboratory methodologies described below contain a statement of TI's quality assurance/quality control procedures applicable to each type of activity. Similar information relative to studies conducted by Sargent & Lundy and the University of Kentucky Research Foundation is available in reports submitted to KU.

5.1 POPULATION DENSITY

5.1.1. Method

Although population estimates within the study area in general were obtained from published sources and agency information, distribution of existing population within a 5-mile radius of the Hancock and Breckinridge sites was determined using color infrared photographs of the study area, ground truthing, and extrapolation. Color infrared photography (described in Section 5.2) was obtained by TI in June 1979 (Table 5.1-1) through subcontract to Air-photo of Lake Forest, Illinois. The photographs were examined and residences within 5 miles of each site were mapped. Occupancy was verified in the field and the population density (dot) map developed.

Per-unit occupancy rates obtained from local planning agencies were used to determine the 16-cardinal-direction and radial distributions for each site. An appropriate grid was placed over the dot map for each site and the dots within each sector were multiplied by the occupancy rate.

Projected population densities within the 5-mile radial areas were based on the distribution determined for the existing population and

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5.1-1. Terrestrial and Human Factors Field Sampling and Reconnaissance Efforts, Kentucky Utilities Hancock Generating Station EIS Program, 1979-1980

Terrestrial Ecology	Period 1979	Period 1980	Location	Cover Types	Number of Samples per Period
Vegetation					
Herbs	Fall	Spring Summer	2 Sites	Upland Hardwoods Lowland Hardwoods Field	15 15 10
Shrubs	Fall	Spring Summer	2 Sites	Upland Hardwoods Lowland Hardwoods	5 5
Trees	Fall		2 Sites	Upland Hardwoods Lowland Hardwoods	30 30
Aquatic Macrophytes	Fall	Spring Summer	2 Sites	Sitewide	1 survey
Vegetation Cover					
Color Infrared Photography	June		2 Sites, their 5-mile radial areas, and transmission corridors	—	—
Groundtruthing	Fall	Spring	Same as above	—	—
Stress survey	Fall	Spring Summer	Same as above	—	—
Reconnaissance		Summer	3 Transmissions corridors		
Wildlife Reconnaissance		Summer	3 Transmission corridors	—	—
Wildlife Observations	Fall	Spring Summer	2 Sites	Sitewide	1 survey
Amphibians and Reptiles					
Drift fence/pitfall	Fall	Spring Summer	2 Sites	Upland Hardwoods Lowland Hardwoods Field Cropland	1 1 1 1
Time counts	Fall	Spring Summer	2 Sites	Same as above	4
Birds					
Belt Transects	Fall	Spring Summer	2 Sites	Same as above	8
Waterfowl	Fall	Winter Spring Summer	2 Sites, Ohio River	Sitewide	1 survey
Roadside Census	Fall	Spring Summer	2 Sites and vicinity	—	1
Mammals					
Live trapping	Fall	Spring Summer	2 Sites	Upland Hardwoods Lowland Hardwoods Field Cropland	4 4 4 4
Belt Transects	Fall	Spring Summer	2 Sites	Upland Hardwoods Lowland Hardwoods Field Cropland	4 4 4 4

Human Factors	Period 1979	Period 1980	Location
Population density	Fall		2 sites and their 5-mile radial areas
Land use patterns	Winter		2 sites, their 5-mile radial areas and transmission corridors
		Summer	Elizabethtown Transmission Corridor
Historic and scenic resources	Summer	Summer	2 sites, their vicinities, and transmission corridors
Scenic resources		Summer	Elizabethtown Transmission Corridor
Archaeology-surface survey	Fall	Spring	2 sites

SOURCE: Texas Instruments (1980)

appropriate county projection ratios. This method limited growth to sectors with existing populations.

5.1.2 Quality Assurance/Quality Control

TI's standard procedures for assuring quality of maps and figures include a check on the data, a check on the hand-drafted version, and a proof of the final production. For the population density map, checks were made to see that all houses were plotted on the draft map. For the cardinal-direction and radial distributions, at least one calculation was recomputed in sectors requiring a different or more than one occupancy rate. The same was done for the projected distributions, using projection ratios. Proofreading of final products is done by two individuals - the person responsible for the specific task and a technical writer.

5.2 LAND USE/LAND COVER

5.2.1 Method

5.2.1.1 Sites and Transmission Corridors

Existing land use/land cover of the 5-mile radial areas of each site and their potential transmission corridors also was determined using aerial color infrared (CIR) photography and ground truthing. The aerial photographs were taken in June so that foliage and any foliar effects would be apparent to facilitate vegetation typing and recognition of stress areas. Scale of the photographs was 1:12,000. The film was Kodak Aerochrome Infrared 2443 (Estar base). The camera was equipped with an appropriate lens and a filter to enhance color differences in the red and near-infrared portion of the spectrum (Eastman Kodak 1976). Forward overlap maintained during the photography was 60% and side overlap was 30%. The film was processed to 9- X 9-inch positive transparencies, which were encased in plastic sleeves for marking.

Vegetation cover types of the photographed area were delineated by placing paired transparencies on a light table and viewing with a mirror stereoscope. Cover types were marked on the plastic sleeves of odd- or even-numbered photographs with a black felt-tip pen. Initial cover type differentiation was accomplished using image tonal variations, physical characteristics, and topography of the area viewed. Each cover type was assigned a numerical code for identification prior to the application of nomenclature. Cover type nomenclature basically was that of the USGS land use/land cover system (Anderson et al. 1976).

Initial groundtruth examinations were conducted in the summer of 1979 for type and boundary verification, correct nomenclature assignment, crop designation, and investigation of stress areas (marked on the plastic sleeves with a blue felt-tip pen). Revisions were incorporated into the final selection of seven vegetation cover types: lowland hardwoods, upland hardwoods, coniferous forests, old fields, cropland and pasture, tree farms, and wetlands. These cover types were combined with five additional land use designations (corridors, residential, industrial, commercial, and water) and mapped as land use/land cover units on a large-scale map for the project area and on a more detailed scale for both sites and their transmission corridors.

Acreages of onsite cover types were determined by tracing each map unit onto graph paper and multiplying the number of squares and partial squares to determine total area. Calculations were reviewed for accuracy of estimates by a second individual and total square footage for each site was checked by using a planimeter.

5.2.1.2 Elizabethtown Transmission Corridor

Land use/land cover of the Elizabethtown transmission corridor was determined by ground truthing existing aerial photography. Black and white aerial photographs of the Elizabethtown corridor from the potential intersection with the proposed tie-in corridor in Hancock County to Elizabethtown, Kentucky were obtained from the U.S. Department of Agriculture Agricultural Stabilization and Conservation Service. The photographs were taken during 1971 and 1972 at a scale of approximately 1:22,000 and were developed into 9- X 9-inch black and white prints.

Current (1980) land use/land cover along the corridor was verified by ground truthing accessible areas. Emphasis was placed on verifying current conditions in locations identified as having aesthetic sensitivity or sites of cultural and biological significance. Features adjacent to the existing corridor were mapped, and land use units were modified as necessary based on ground truthing data.

5.2.2 Quality Assurance/Quality Control

Field reconnaissance to verify cover-type identification and delineation from the CIR photographs was conducted over 95% of the area within boundaries of the two sites, 75% of the two corridors, and 40% of the remaining study area. Photographs were taken to document cover-type designations on the sites.

QA/QC procedures for land use/land cover mapping included recomputation of about 10% of the map units to check consistency of calculations. Other QA/QC methods were similar to those mentioned in Section 5.1.2.

5.3 CULTURAL FACTORS

Three aspects of the cultural environment involved field analysis - visual or aesthetic resources, historic resources, and archaeological resources. Historic and archaeological resources were surveyed on the two sites and their potential evaluated for other locations in the study area. Visual resources were examined throughout the study area.

5.3.1 Methods

5.3.1.1 Visual Resources

Scenic quality and aesthetic setting were evaluated qualitatively, generally following the landscape inventory framework method developed by Litton and Tetlow (1978). Guidelines of the Bureau of Land Management (1975) and the U.S. Forest Service (Litton 1968, Daniel and Boster 1976) were consulted. These methodologies consider landscape character based on several factors and evaluate impact relative to the magnitude of contrast the project would create.

Visual characteristics of the landscape were recorded from both aerial and ground observations. Locations of visually sensitive areas (e.g., ridges, waterbodies) within the study area were identified by examining the CIR transparencies and black and white USDA aerial photographs. USGS topographic maps (scale 1:24,000) were used to identify variations in topography and potentially unique land forms.

Ground reconnaissance was conducted by automobile in the four counties of the study area. Both major and minor roads were covered in a series of loops to assess broad characteristics of the region as well as unique or striking visual components. Landscape diversity was documented and analyzed based on four fundamental elements:

- Land form characteristics
- Vegetation cover and patterns
- Water presence and patterns
- Land use patterns (i.e., manmade changes).

Field information pertinent to these four elements was collected by recording: (1) the usual, relatively homogeneous settings as well as the unusual; (2) visual boundaries or edges between different land forms and vegetation; (3) water and riparian zones in the landscape; (4) towns and farmsteads; (5) examples of impacts (existing forms and structures that appear in conflict with their surroundings; and (6) impacts that are compatible with the adjacent landscape. Photographs were made of selected views and land forms; site characteristics were recorded, and site locations mapped.

5.3.1.2 Historic Resources

Information on the history of Hancock and Breckinridge counties was compiled by the University of Kentucky in their cultural resource assessment report (University of Kentucky, Department of Anthropology, Archaeological Report 30, 1980). Investigation of the Hancock and Breckinridge sites included a literaure search of prehistoric and historic cultural history, an extensive on-foot inspection of prehistoric and historic archaeological sites, and documentation of standing structures and cemeteries. The assessment was conducted in compliance with provisions of the National Historic Preservation Act of 1966 (16 U.S.C. 470), the National Environmental Policy Act of 1966 (Public Law 91-190, as amended), Executive Order 11593 of May 13, 1971 (36 CFR 9821), and "Specifications for Archaeological Reports" jointly promulgated by the Kentucky Office for State Archaeology and the Kentucky State Historic Preservation Office (Kentucky Heritage Commission).

Field surveys included identification and photographic (black and white) documentation of structures 50 years or older on both sites and those in view of either site or the Elizabethtown corridor. The photographs, short descriptions of the structures, and maps showing locations of the structures were reviewed by an architectural historian (Langsam, personal communication

1980). The findings of the historian were submitted to the Kentucky Heritage Commission for final evaluation of historic potential and possible nomination of structures for the National Register of Historic Places.

5.3.1.3 Archaeological Resources

The archaeological survey included a background search of existing literature and records of references to the known cultural resources in the Hancock study area and an on-foot survey of both recorded and unrecorded archaeological resources on and near each site. Both the background search and the survey were executed in compliance with provisions of the National Historic Preservation Act of 1966, as amended, (16 U.S.C. 470) and "Specifications for Archaeological Reports" jointly promulgated by the Kentucky Office for State Archaeology and the Kentucky State Historic Preservation Office (Kentucky Heritage Commission). Prior to field work, archaeological site files and technical reports at the Office of State Archaeology were examined for previously reported archaeological sites. Other pertinent data on archaeological sites were gleaned from the University of Kentucky Margaret King Library and the geology library.

5.3.1.3.1 Field Survey

The archeological resources survey included an intensive on-foot examination of all accessible properties on each site. Access and permission to collect artifacts were granted for most of the Hancock site and approximately 65% of the Breckinridge site. All survey forms, notes, photographs, and cultural materials collected from the site areas are curated at the University of Kentucky Museum of Anthropology, Lexington, Kentucky. The detailed survey data were reported in a separate volume that has been distributed to the Kentucky Heritage Commission and EPA Region IV.

In the field, the four members of the survey team lined up at 10- to 15-meter intervals (depending on conditions) and traversed the area in systematic parallel sweeps. Where ground visibility was obscured in dense grass or in secondary-growth hardwood forest, loss of data was minimized by shoveltesting at 10- to 15-meter intervals. In shoveltesting, a shovel full of earth was removed and the fill closely examined for cultural materials. Land devoid of vegetation, such as cultivated fields, animal trails, erosional cuts, or other barren spots, was carefully inspected.

When an archaeological site was encountered, the survey team attempted to determine the extent of the cultural materials as well as any high-density concentrations of artifacts. On small sites all observed artifacts were recovered. At large sites only a sample of cultural materials was taken. The survey team selected diagnostic artifacts, examples of nondiagnostic artifacts, and raw material types for the sample. When feasible, areas of artifact concentrations were bagged separately.

Survey forms were filled out and photographs taken of all archaeological sites.

5.3.1.3.2 Laboratory Procedures

All collected archaeological data were taken to the cultural resource laboratory for processing. Initially, all artifacts were washed and catalogued using the system employed by the University of Kentucky Museum of Anthropology. Subsequently, each artifact was placed into a typological category. Analyses of the artifacts followed the typology established by the University of Kentucky for previous archaeological research projects. This typology is based primarily on a nested hierarchical taxonomy that depicts each artifact or artifact group. Information on each artifact recovered during the project was placed in a computer data storage and retrieval system.

5.4 AIR QUALITY

Ambient air quality and meteorological monitoring were conducted on each site from July 1, 1979 to July 1, 1980. Locations of monitoring stations are shown in Figures 5.4-1 and 5.4-2. Air monitoring sites 1 and 2 were on the Hancock site and air monitoring site 3 was on the Breckinridge site. Meteorological parameters measured were wind speed, wind direction, and ambient temperature. Air quality parameters monitored were sulfur dioxide, ozone, and total suspended particulates (TSP). TSP measurements were taken each six days, while the other parameters were monitored continuously.

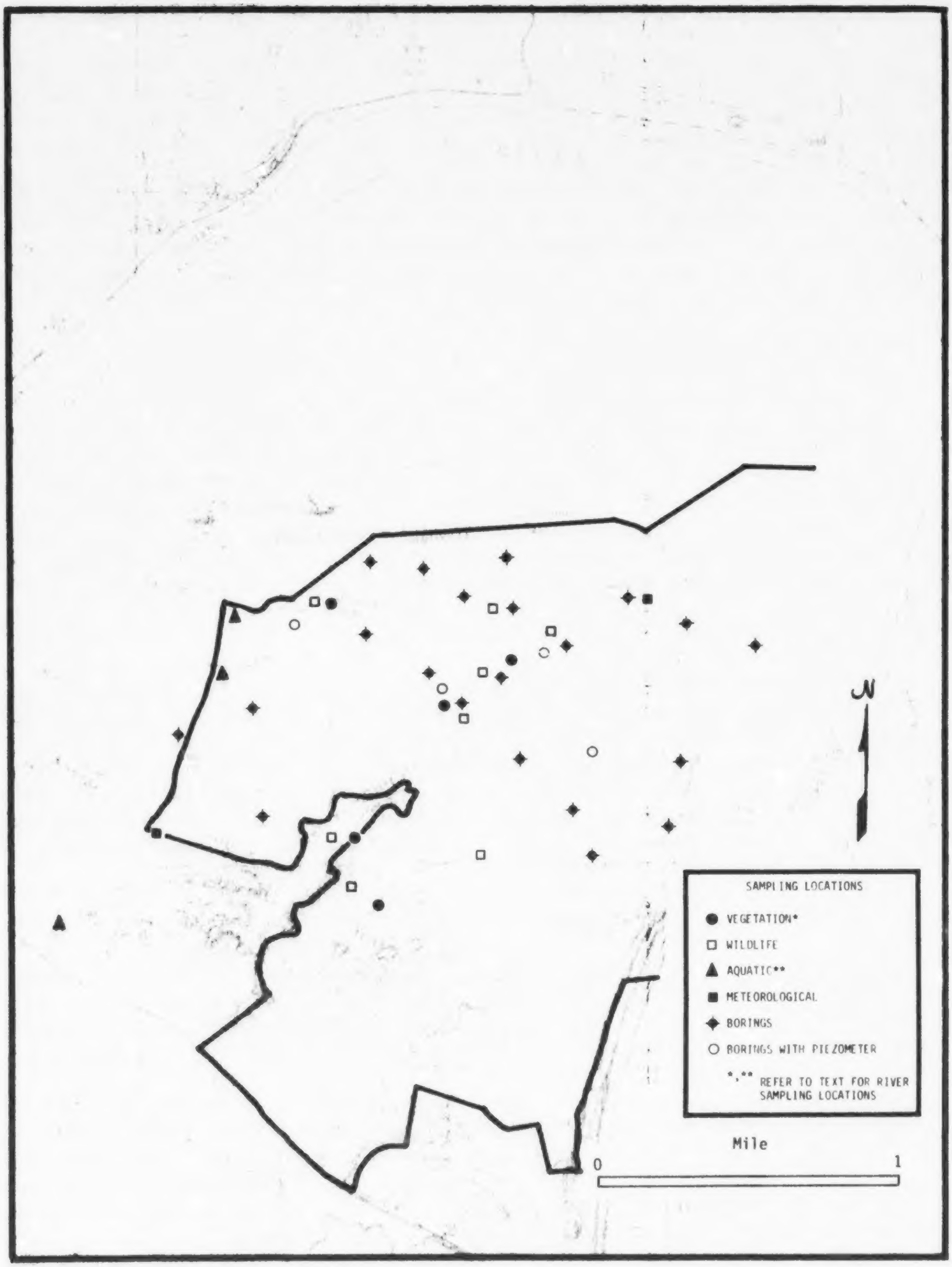
5.4.1 Instrumentation

Equipment used in the air program, as well as the monitoring sites, were EPA approved and met or exceeded EPA criteria for PSD monitoring, as determined by the EPA-authorized Division of Air Pollution Control of the Kentucky Department for Natural Resources and Environmental Protection. The instrumentation and data acquistion systems were housed in 8- by 12-foot shelters that maintained a stable internal temperature. Meteorological sensors were mounted on 10-meter meterological towers, and TSP samplers, were mounted on the roof of each shelter.

5.4.1.1 Meteorological Instruments

Wind Speed. Wind speed was measured by a 3-cup anemometer (Weathertronics Model 2030) that produced a pulsed output at a rate proportional to wind speed. A signal conditioning module converted anemometer output to an analog voltage proportional to wind speed.

Wind Direction. Wind direction was measured by a Weathertronics Model 2020 Micro-Response Vane mounted on a crossarm that offset the sensor from the tower and minimized aerodynamic interference. The vane turned a shaft connected to a potentiometer. A signal-conditioning module converted resistance of the potentiometer to a standard voltage that drove a strip-chart recorder.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SAMPLING LOCATIONS
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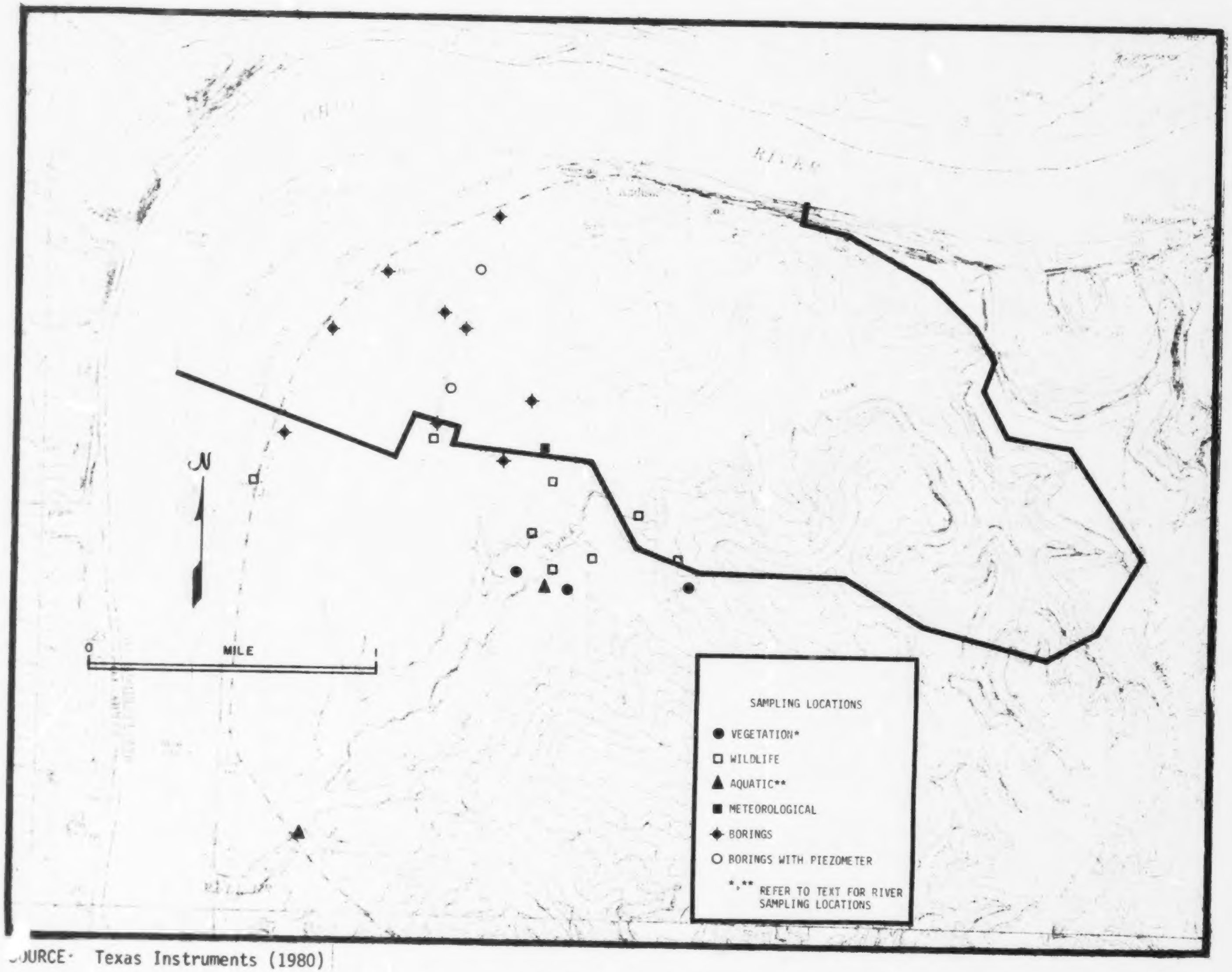
SOURCE: Texas Instruments (1980)

Figure 5.4-1. Hancock Site Sampling Locations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▲ AQUATIC**
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◆ BORINGS
○ BORINGS WITH PIEZOMETER
*,** REFER TO TEXT FOR RIVER SAMPLING LOCATIONS

URCE· Texas Instruments (1980)

Figure 5.4-2. Breckinridge Site Sampling Locations

Ambient Temperature. The air temperature sensor was a thermistor temperature probe (Weathertronics Model 4480). The sensor consisted of a 3-element thermistor that produced large changes in resistance inversely proportional to small changes in temperature. A fan-aspirated radiation shield prevented errors due to direct sunlight on the probe. A signal-conditioning module converted resistance changes to an analog signal proportional to temperature.

5.4.1.2 Air Quality Instrumentation

Air quality instrumentation at each site consisted of continuous monitors for ozone and sulfur dioxide and high-volume air samplers for collecting suspended particulates.

Sulfur Dioxide. Ambient sulfur dioxide concentrations were measured by a Monitor Labs Model 8450 Sulfur Monitor, which is a flame photometric detection device that performs continuous dry analysis for sulfur compounds. Its operation was based on chemiluminescence of an activated molecular sulfur species produced by a hydrogen hyperventilated diffusion flame. A photomultiplier tube measured the intensity of the chemiluminescent emission. Specificity for sulfur dioxide was provided by a scrubber that eliminated interference from hydrogen sulfide.

Ozone. Ambient ozone concentrations were measured by a Monitor Labs Model 8410 Ozone Analyzer, which is a gasphase chemiluminescence detector. Its operation was based on chemiluminescence of an activated aldehyde species produced by a chemical reaction of ozone with ethylene. A photomultiplier tube measured the intensity of the chemiluminescent emission and, after processing, produced a voltage porportional to the ambient ozone concentration.

Suspended Particulate. TSP samples were collected by General Metal Works high-volume air samplers. TSP determinations were calculated from measurements of the difference in weight between exposed and clean filter papers relative to the volume of air passed through the filters in a 24-hour period. Twenty-four-hour samples were collected at each site every six days.

5.4.1.3 Data Acquisition System

A Monitor Labs 9300 Data Logger processed signals from meteorological and air quality instrumentation for recording on a reel-to-reel magnetic tape recorder. The data were also recorded on continuous stripchart recorders, which provided redundancy for the system. Magnetic tapes were converted into SAROAD report format.

5.4.1.4 Quality Assurance/Quality Control

Quality assurance procedures for atmospheric data collecting were approved by the Kentucky DNREP Division of Air Pollution Control. The QA program included daily zero-span checks, appropriate calibration for each instrument not within span limits, and quarterly audit procedures. The program met minimum requirements as specified in 40 CFR 58, Appendix B. EPA publication, Ambient Monitoring Guidelines for Prevention of Significant Deterioration, was used as a guideline.

Control Checks. Daily zero-span checks were performed on both sulfur and ozone monitors. Results of these checks were plotted on control charts. Corrective action was taken whenever control limits were exceeded.

Calibration. Dynamic multipoint calibrations of ozone and sulfur dioxide monitors were performed using NBS-traceable gaseous standards. Test concentrations for ozone were obtained in accordance with the UV photometric standard. All flow measurements were made by instruments traceable to NBS standards. Meteorological instruments were calibrated in accordance with the manufacturer's instructions.

Audits. Independent multipoint audits of ozone and sulfur dioxide monitors were performed by the Commonwealth of Kentucky each three months.

5.5 SUBSURFACE INVESTIGATIONS

Subsurface investigations conducted to date have included borings to determine structural stability of each site, groundwater availability on each site, and sampling to determine groundwater quality representative of the study area. Drilling to determine structural stability occurred at 21 locations on the Hancock site and 10 locations on the Breckinridge site (Figures 5.4-1 and 5.4-2). Groundwater availability data were collected from four of these borings on the Hancock site and from three of the borings on the Breckinridge site. Groundwater quality data were collected at three existing wells on the Hancock site. Additional subsurface data will be collected during preconstruction site work.

5.5.1 Test Borings

Borings data were obtained from each site during May 1978 and April and May 1979. Borings were drilled using truck- or all-terrain-vehicle-mounted auger/rotary wash-type equipment. The 1978 borings were tested by H.C. Nutting Company and the 1979 borings were tested by Law Engineering Testing Company.

Piezometers were installed in selected borings on each site in May 1979 to record groundwater conditions. Readings were taken eight times from June to November 1979.

5.5.2 Groundwater Quality

Water samples were taken from the Hancock site wells (designated McIntyre, Shearn, and Trailer) once in March 1980 and once in May 1980. Groups of parameters analyzed included anions, cations, and trace inorganics; pH, fecal coliform, inorganic and organic carbon, dissolved and suspended solids, and specific conductance also were measured. Analyses were performed by NUS Corporation.

5.6 VEGETATION

In addition to vegetation covertyping described in the land use/land cover methodology, vegetation analysis included determination of vegetation stress within each alternative site's 5-mile radial area and potential transmission corridor and vegetation surveys on each site to determine composition, condition, and status of each cover type.

5.6.1 Vegetation Stress

Apparently stressed vegetation, noticeable because of loss of infrared reflectance from its foliage, was delineated on the color infrared (CIR) transparencies during photointerpretation. Stress areas of 5 acres and greater were field checked for stress verification and determination of causal agent(s). Stress within coniferous forests was checked during spring 1980, and stress on hardwoods was checked during summer 1980. Color photographs (35-millimeter) were taken to document plant species/stress agent associations. Plant voucher specimens were collected when possible. Stress locations were then plotted on a map of the study area and assigned a number for reference to causal agents. Stress areas of less than 5 acres are documented on the CIR transparencies for future monitoring purposes.

5.6.2 Vegetation Surveys

Examination of CIR photographs and groundtruth data indicated that there were three extensive cover types and three minor cover types on each study site. Major types included lowland hardwoods, upland hardwoods, and cropland and pasture. Minor types were old fields, coniferous forests and wetlands. The cropland and pasture cover type included both cultivated and fallow fields. Since the cultivated fields were primarily a monoculture, which does not require sampling to determine species composition, only the fallow fields in this type were sampled. Major cover types were sampled, while the less extensive cover types were surveyed using walk-through techniques.

5.6.2.1 Vegetation Sampling

Sampling locations for the major cover types on each site (Figures 5.6-1 and 5.6-2) were selected on the basis of initial field reconnaissance and CIR photography. The nature, complexity, and seral (successional) stage of existing vegetation, as well as the soil and history of land use, were considerations in their determination. Vegetation was categorized into three strata for sampling purposes. Table 5.6-1 defines the size criteria for the three vegetation strata.

The tree stratum was sampled in fall 1979, and herbaceous and shrub strata were sampled at that time and in spring and summer 1980.

Table 5.6-1. Size Definitions for Vegetation Strata

Stratum	Diameter cm (inches)	Height m (feet)
Herbs	–	≤1 (3.3)
Shrubs	<8.89 (3.5)	>1 (3.3)
Trees	≥8.89 (3.5)	>1 (3.3)

SOURCE: Texas Instruments (1980).

5.6.2.1.1 Trees

The tree stratum was sampled using the point-quarter method (Cottam and Curtis 1956). Applicability of this method (random distribution and closeness of individuals in the tree stratum) was verified during field reconnaissance on the Hancock and Breckinridge sites (Mueller-Dombois and Ellenberg 1974, Brower and Zar 1977).

Point-quarter sampling was conducted by randomly running either a 150-meter or three 50-meter transects through lowland hardwoods and upland hardwoods cover types on each site. (Fallow fields did not have a tree stratum.) Thirty points, or sampling stations, were located at approximately 5-meter intervals on each transect (or set of transects). At each point, the area was divided into four quadrants by bisecting the transect line with a perpendicular line. The nearest tree in each quadrant was identified, the distance from the point to each of the four trees was measured, and diameter at breast height (dbh) of each sampled tree also was measured.

Distance measurements were used to calculate relative density and relative frequency of each tree species per cover type. Diameter at breast height was used to derive relative cover values. These three values were summed to determine an importance value for each species, which is an overall estimate of the importance or influence of a species in the cover type.

Calculations were based on standard ecological analyses (Brower and Zar 1977), using these definitions and steps:

- Density: the number of individuals of a species in a unit area

$$\text{mean point-to-plant distance} = \frac{\text{sum of point-to-plant distances for all individuals}}{\text{total number of individuals measured}}$$

$$\text{mean area per plant} = (\text{mean point-to-plant distance})^2$$

$$\text{total density of all species} = \frac{\text{number of area units}}{\text{mean area per plant}}$$

$$\text{density} = \frac{\text{number of individuals per species}}{\text{total individuals of all species}} \times \text{total density of all species}$$

- Relative density = the number of individuals of a species as a proportion of the total number of individuals of all species

$$\text{relative density} = \frac{\text{density of a species}}{\text{total density of all species}} \times 100$$

- Frequency = the chance of finding a given species within the unit area sampled

$$\text{frequency} = \frac{\text{number of sampling points where species occurred}}{\text{total number of points sampled}}$$

- Relative frequency = frequency of a species as a proportion of the sum of frequencies for all species

$$\text{relative frequency} = \frac{\text{frequency of a species}}{\text{total of frequencies of all species}} \times 100$$

- Coverage (in tree strata) = area occupied by the bases of a species

$$\text{Basal area of an individual} = \pi \left(\frac{\text{dbh}}{2}\right)^2$$

$$\text{coverage} = \frac{\left(\text{[illegible] of basal areas of a species}\right) \times \left(\text{density of a species}\right)}{\text{total individuals of the species}}$$

- Relative coverage = coverage for a species expressed as a proportion of the total coverage for all species

$$\text{relative coverage} = \frac{\text{coverage for a species}}{\text{total coverage for all species}} \times 100$$

- Importance value = the sum of the three relative measures

importance value of a species = relative density
+ relative frequency
+ relative coverage

5.6.2.1.2 Herbs and Shrubs

Herbaceous and shrub strata were sampled using a modification of the releve method of data collection (Benninghoff 1966). The technique provided an estimate of species composition in each stratum per cover type and cover- and density-class ratings and frequency for each species sampled. The ratings and frequency of each species were used to estimate its importance in the community.

Sampling was conducted in each cover type in standard-sized plots (25-square-meter plots for shrubs and 1-square-meter plots for herbs). Each time a species was encountered it was assigned a cover and density rating relative to that plot (Table 5.6-2). During fall 1979 surveys, shrubs and herbs were sampled in the hardwood types concurrently with trees along the same transects. Thereafter, they were sampled on different transects in the hardwoods as well as in fallow fields to more completely describe vegetation composition of each cover type. Each sampling comprised a minimum of 5 plots per cover type for shrubs and 15 plots for herbs, except in fallow fields, where vegetative uniformity required only 10 plots for herbs. Herbaceous plots were spaced at 10-meter intervals and shrub plots at 30-meter intervals.

Table 5.6-2. Cover- and Density-Class Ratings for Herbaceous and Shrub Vegetation

Cover Ratings	
5	covering more than 75% of the sample plot
4	covering 50 to 75% of the sample plot
3	covering 25 to 50% of the sample plot
2	covering 5 to 25% of the sample plot
1	covering 2.5 to 5% of the sample plot
+	covering less than 2.5% of the sample plot

Density Ratings	
4	more than 100 individuals
3	11 to 100 individuals
2	2 to 10 individuals
1	1 individual

An individual is a single stem or a well-defined clump.

Source: Benninghoff (1966).

For analysis, a mean cover- and density-class rating was calculated for each species per cover type per sampling period. These mean ratings were transformed to the middle vaues in the cover and density classes to obtain a mean percentage cover and mean density-per-unit-area for each species. Frequency was determined by counting the number of plots in which a species was listed and dividing by the total number of plots sampled Relative frequency, relative cover, and relative density were calculated according to standard analyses described above for trees.

In addition to species data, other pertinent information recorded at the sampling stations included slope, aspect, percent tree cover, percent shrub cover, percent ground cover, percent litter, and percent bare ground.

5.6.2.2 Walk-through Surveys of Minor Cover Types

Old fields, coniferous forests, and wetlands on the sites were surveyed by walk-throughs that provided species abundance. Two old fields were surveyed on each site. The only coniferous cover type was a small pine stand planted by a landowner on the Hancock site. The wetlands cover type included those areas near each site officially recognized by the Kentucky Department of Fish and Wildlife Resources as wetlands, as well as marshy areas associated with ponds, wet meadows, and periodically flooded areas associated with streams. Because of its sensitivity, sapling of this cover type was not restricted to the proposed boundaries of the sites. Aquatic plants in each area were identified.

5.6.3 Quality Assurance/Quality Control

As in the case of wildlife surveys (described below) most vegetation data are recorded in the field to minimize collecting. Thus, personnel performing vegetation surveys were experienced botanists who were familiar with regional vegetation and appropriate sampling methods.

Field guides and identification manuals were used to aid in identification of plant species. Species that could not be identified in the field because of complex diagnostic characteristics or immaturity were collected for later determination. Immature species were checked in subsequent sampling periods at maturity and changes in plant growth verified their identity.

Unusual events and/or indications of vegetation stress were photographed for documentation, and local foresters were consulted for identification or verification of certain stresses. This was especially important in identification of weather-induced stress.

During data analysis, a minimum of 10% of each of the population characteristics calculated from the data were recalculated to insure consistency of analysis and to check accuracy. Tables and figures were checked before and after they appeared in final form. Draft reports were reviewed by [illegible] associated [illegible].

5.7 WILDLIFE

Wildlife was surveyed in the upland hardwoods, lowland hardwoods, cropland, and fallow field cover types and major waterbodies of each site (Figures 5.4-1 and 5.4-2) during October 1979 and May and July 1980; an aquatic bird survey also was conducted in December 1979. Wildlife habitats within the two potential transmission corridors and the Elizabethtown transmission corridor were evaluated in July for similarity to those onsite and for presence of unique areas. Wildlife groups surveyed were amphibians and reptiles, birds, and mammals. All sampling data were field observations, and all captured animals were released. Data were recorded in field notebooks and transferred to a standard data sheet (TI form 23112) prior to computation. Results of specific surveys were computed by calculator. Checklists and relative abundance estimates included these results as well as observations at times other than during specific sampling.

5.7.1 Amphibians and Reptiles

Two sampling methods were used to survey these species: drift fence/pitfall traps and time counts. Much of the data on frogs and toads was obtained during random nighttime surveys of major aquatic habitats on the sites.

Drift fence/pitfall traps. One drift fence structure, comprising 30-centimeter-high, 10-meter-long hardware cloth and three evenly spaced, 45-centimeter-deep, entrenched buckets, was constructed in a selected location in each vegetation cover type on each site. The fences were monitored for three nights in each location each sampling period. The structures were removed and the bucket holes filled after each survey.

Time Counts. One hour was spent during each sampling period in each cover type turning logs, rocks, and other objects to search out hidden species.

Chorus Surveys. Streams, ponds, and flooded areas of each site were surveyed for observations and chorus activity two nights on each site during the spring and summer sampling periods to determine breeding populations and breeding locations of anurans.

5.7.2. Birds

Birds were surveyed using road route and belt transect census methods during each sampling period. Aquatic birds were observed at appropriate locations.

Road Route. Frequencies of bird species in cover types of the site and adjacent locations were determined by establishing a 20-kilometer, 25-stop road survey route at each site. Each route was driven once each sampling period during early morning in still, dry weather. Three minutes were spent at each stop looking and listening for birds.

Belt Transect. Bird densities in each vegetation cover type were estimated by an Emlen transect method (Emlen 1971) untilizing two 100-meter transects per cover type. The width of each transect varied and was based on habitat visibility. Each transect was walked during early morning once each sampling period.

Aquatic Survey. Ohio River miles 702 to 707 and 714 to 722 and major onsite aquatic locations were surveyed for bird usage once during each wildlife sampling period and during December. Vantage points were selected on both the Kentucky and Indiana sides of the river. The December and May surveys also included observations by boat.

5.7.3 Mammals

Mammals as a whole were surveyed on both sites using mark/recapture and belt transect methods, and the eastern cottontail rabbit specifically was surveyed on the road route established for each site. A presampling survey for bats was conducted on each site. Bats were sampled by mist netting on the Hancock site only in the Jeffry Cliff area where signs and habitat were noted during site reconnaissances.

Mark/recapture. Small mammals such as shrews and mice were surveyed each sampling period by using Sherman live-traps set at 10-meter intervals along a systematically selected 250-meter-long transect in each vegetation cover type. the 25 traps in each location were baited with a mixture of rolled oats and sunflower seeds and set for four consecutive nights each sampling period. They were checked daily, captured animals were marked by toe clipping, sex was recorded, and animals were released. The number of individuals marked was the basis for deriving relative abundance of the species in the cover type:

$$\begin{array}{l}\text{Relative abundance of a species}\\ \text{(number per 100 trap-nights)}\end{array} = \frac{\text{number of individuals marked}}{\text{number of trap-nights}} \times 100$$

Belt transects. Large mammal abundances in each vegetation cover type were estimated using the two 100-meter transects surveyed for birds. The mammal transects were surveyed once each sampling period for tracks, scats, other signs, and sightings.

Road Route. The 25-kilometer road route of each site was driven slowly once each sampling period during early morning to count eastern cottontail rabbit. Survey data yielded relative numbers of rabbits per kilometer segment of the route.

Mist Nets. To assess bat activity, a standard mist net for capturing birds and bats was monitored once each sampling period during dusk and early evening hours at 2 locations near Jeffry Cliff on the Hancock site. Captured bats were released immediately after being identified.

5.7.4 Quality Assurance/Quality Control

All wildlife surveys were conducted by a knowledgeable, experienced wildlife biologist. Appropriate aids were used, including field glasses, field guides, and tape recorders. Appropriate literature was reviewed prior to field work.

Sampling gear was checked daily for reliability. Each pit trap was cleared of debris and fence structures checked for ground contact. Release treadles of Sherman live-traps were checked to assure capture of all mammals that entered. Mist nets were checked for tears and repaired as necessary.

Records of sex of small mammals aided recognition of a recaptured animal whose mark was disturbed or questionable.

When data were transferred from field notebooks to data sheets, all transfers were checked for completeness and accuracy. One data set of each type of computation was recalculated as a check on appropriate data column entry. Tables, figures, and draft text were treated as described for vegetation data analysis.

5.8 AQUATIC ENVIRONMENT

Aquatic investigations in the project area included sampling and data analysis to determine present conditons and aquatic fauna of the Kentucky side of the Ohio River and the onsite streams. Additionally, streams within the potential transmission corridors of each site were surveyed for physical characteristics and sampled for certain water-quality parameters. The aquatic field program began in June 1979 and was completed in July 1980. Sampling frequency and sample numbers are in Table 5.8-1; on-site sampling locations are shown in Figure 5.4-1 and 5.4-2.

5.8.1 Water Quality

Water quality sampling for the study was designed to supplement data collected at the Cannelton Lock and Dam by the Ohio River Valley Water Sanitation Commission (ORSANCO).

5.8.1.1 Field Procedure

Temperature and dissolved oxygen profile data were collected 10 times during the aquatic sampling program at 5 points on transects at Ohio River miles 705, 707, 715, 717, and 722 to determine stratification. Dissolved oxygen, temperature, and conductivity were measured *in situ* in conjunction with all aquatic biota sampling to determine conditions at the time of sampling. The latter data were collected when taking aquatic biota samples from onsite streams as well as during Ohio River sampling.

Water samples to determine concentrations of heavy metals (Be, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, Zn) were taken at random points along the Ohio River in the study area during August 1979 and May 1980. These samples were collected in polyethylene containers, fixed with acid to stabilize the contents, and shipped to TI's Dallas laboratory for analysis. Additionally, fish tissues were collected during both the 1979 and 1980 sampling periods to

Table 5.8-1. Aquatic Sampling Efforts, Hancock Generating Station EIS Program, 1979-1980

Parameter and Method	Stations Ohio River and Streams	Month and Number of Samples 1979 Jun	 Jul	 Aug	 Sep	 Dec	 1980 Apr	 May	 Jun	 Jul	Total
Fish											
Gill nets	RM 707, 717, 722	5	6	6	–	–	–	6	3	–	32
Seines (river)	RM 705, 707, 715, 717, 722	6	8	8	–	–	8	8	4	–	44
Electrofishing	RM 705, 707, mouth of Town Creek, 715, 717, 722	12	12	12	–	–	12	12	6	–	66
Seines (streams)	Indian Creek (1), Muddy Branch (1), Sandy Branch (1), Town Creek (2)	*	*	5	–	–	5	5	5	5	25
Fish eggs and larvae	RM 705, 707, 715, 717, 722	100	100	125	–	–	100	100	25	–	550
Benthos											
Ponar	RM 705, 715, 717, 722	12	12	–	12	12	12	–	–	–	60
Ekman	Indian Creek (1), Muddy Branch (1), Sandy Branch (1), Town Creek (2)	–	*	–	5	5	5	–	–	5	25
Drift	Indian Creek (1), Muddy Branch (1), Sandy Branch (1), Town Creek (2)	–	*	–	5	5	5	–	–	5	25
Macroplankton	RM 705, 707, 715, 717, 722	25	25	25	–	–	25	25	–	–	125
Mussels	RM 702 through 722	–	–	X	–	–	–	X	–	–	2 times
Water quality											
Temperature and dissolved oxygen profiles	RM 705, 715, 717, 722	*	50	50	25	–	50	50	25	–	250
Metals	Points between RM 705 and 722	–	–		4	–	–	3	–	–	7
Tissues:											
Muscle	From 6 most abundant rough and game species	–	–	–	[illegible]	–	–	[illegible]	–	[illegible]	[illegible]
Liver		–	–	–	[illegible]	–	–	[illegible]	–	[illegible]	[illegible]
Gills		–	–	–	[illegible]	–	–	[illegible]	–	[illegible]	[illegible]
Whole body											
Forage	Most abundant	–	–	–	[illegible]	–	–	[illegible]	–	–	[illegible]
Mussels	Most abundant	–	–	–	[illegible]	–	–	[illegible]	–	–	[illegible]
BOD (5-day)	Indian Creek (1), Muddy Branch (1), Sandy Branch (1), Town Creek (2)	*	*	5	5	5	5	5	5	5	35
Total dissolved solids	Indian Creek (1), Muddy Branch (1), Sandy Branch (1), Town Creek (2)	*	*	5	5	5	5	5	5	5	35
	Indian Creek (1), Blackford Creek (1), [illegible]							5		5	10
Total suspended solids	Indian Creek (1), Muddy Branch (1), Sandy Branch (1), Town Creek (2)	*	*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Indian Creek (1), Blackford Creek (1), [illegible]							[illegible]		[illegible]	[illegible]
Turbidity	Indian Creek (1), Muddy Branch (1), Sandy Branch (1), Town Creek (2)	*	*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Indian Creek (1), Blackford Creek (1), [illegible]							[illegible]		[illegible]	[illegible]
pH	Indian Creek (1), Muddy Branch (1), Sandy Branch (1), Town Creek (2)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Indian Creek (1), Blackford Creek (1), [illegible]							[illegible]		[illegible]	[illegible]

– No samples scheduled.

* [illegible]

[illegible]

Source: [illegible]

analyze for heavy metals concentrations. The desired quota of muscle, liver, and gill tissues from the six most abundant fish collected and whole bodies of forage species was not obtainable during either sampling period. A similar analysis was planned for mussels, but none was collected. Tissue and whole-body samples actually collected and analyzed are shown in Table 5.8-1.

Water samples to determine total dissolved solids (TDS), total suspended solids (TSS) turbidity, pH, and biochemical oxygen demand (BOD) were taken once during August, September, December 1979, and April through July 1980 from onsite streams. All parameters except BOD were measured during May and July 1980 at one location in each of the streams within the potential transmission corridors. Samples for BOD analysis were incubated for 5 days at the Tell City, Indiana municipal sewage treatment plant. The others were iced and sent to Dallas for analysis.

5.8.1.2 Field Quality Assurance/Quality Control

TI's standard QA/QC procedures for aquatic sampling were employed. Instrumentation appropriate for the sampling activity is used during all field efforts requiring in situ analysis of temperature, conductivity, and dissolved oxygen. The instruments were standardized prior to each field effort and calibrated. Calibration followed methods outlined in manuals prepared by the manufacturer.

Each sample collected in the field was identified by labeling. Sample collection data for each sample also were entered by field personnel on a standard TI Ecological Services Sample/Data Progress sheet (TI form 23123). These sheets, which also were coded for desired analysis, were copied, packaged in a moisture-proof envelope, and placed in a shipping container with the appropriate samples.

Samples received in Dallas were inventoried and checked against the Sample/Data Progress Sheet. Discrepancies or damage, if any, were noted on the appropriate sheet and on a standard Extraordinary Event/Nonconformity Report (EE/NC) (TI form 23134). Sample/Data Progress Sheets and EE/NC Reports were then given to the appropriate laboratory and the samples logged in and stored or processed as necessary. Stored samples were logged out on the Sample/Data Progress Sheets for analysis. Results of water quality analysis were entered on a standard analysis sheet (TI form 23315), which was checked for completeness and attached to the progress sheet. The sheets were then submitted to the program administrator, who logged them and gave them to the program manager or to the Data Center for computerization, as appropriate for the program. Final recipient of data was the interdisciplinary team member responsible for its interpretation.

If an EE/NC Report was filed, appropriate actions were initiated by the program administrator. The action and results or recommendations were recorded on the form, which was placed with the data sheets in the program files.

5.8.1.3 Laboratory Procedures

Laboratory and in situ analyses of physical and chemical water-quality parameters and metals concentrations followed EPA approved methods (Table 5.8-2).

Table 5.8-2. Water Quality Analyses, Hancock Generating Station EIS Program

Parameter		Method	Preservation	Reference
Temperature		Thermistor	*in situ*	YSI Manual/ APHA 1975
Dissolved Oxygen (DO)		Membrane Electrode/ Winkler	*in situ*/ Cool, 4°C	YSI Manual/ APHA 1975
pH		Electrode Method	Cool, 4°C	EPA 1979
Turbidity		Nephelometric	Cool, 4°C	EPA 1979
Biochemical Oxygen Demand (BOD)		Incubation/Titration	Cool, 4°C	EPA 1979
Total Suspended Solids (TSS)		Gravimetric	Cool, 4°C	APHA 1979
Total Dissolved Solids (TDS)		Gravimetric	Cool, 4°C	APHA 1979
Heavy Metals*				
Barium	(Ba)	AA-HGA	HNO_3, pH 2	EPA 1979
Cadmium	(Cd)	↕		
Chromium	(Cr)	↕		
Copper	(Cu)	↕		
Iron	(Fe)	↕		
Lead	(Pb)	↕		
Manganese	(Mn)	AA-HGA		
Mercury	(Hg)	Flameless Vapor		
Nickel	(Ni)	AA-HGA		
Selenium	(Se)	↕		
Silver	(Ag)	↕		
Zinc	(Zn)	AA-HGA		

*Metals, except mercury, were analyzed using a Perkin-Elmer 306 atomic absorption spectrophotometer.

SOURCE: American Public Health Association 1975. Standard Methods for Examination of Water and Wastes 14th Ed.

Environmental Protection Agency 1979. Manual of Chemical Analysis of Water and Wastes, 1979.

5.8.1.4 Laboratory Quality Assurance/Quality Control

All water quality analyses used replicates and blanks for comparing results. Spiked samples and reagent blanks were used during atomic absorption analysis. Reagent blanks consisted of reagents that had been processed through all of the sample processing procedures. Samples were retained until the program manager instructed disposition.

Turbidity and pH meters were calibrated according to manufacturers' instructions before analysis of each sample set. Calibration of atomic absorption analyses was carried out by successive dilution of commercial standards. Blanks values were determined for water used for dilution. Standards were replaced at least yearly and new standards were compared with the old before being accepted. Standards with concentrations less than 10 ppm were made fresh daily.

5.8.2 Aquatic Fauna

Aquatic faunal groups surveyed in the Ohio River and on-site streams included fish, benthos, and macroplankton.

5.8.2.1 Fish

5.8.2.1.1 Field Procedure

Four sampling techniques surveyed fish of the study area.

Gill Nets. Graduated mesh gill nets (300-feet in 50-feet panels from 1 to 3 1/2 inches in 1/2-inch increments) were set overnight at Ohio River miles 707, 717, and 722 nine times during the sampling program. All fish collected were identified in the field if possible, weighed, measured, and externally examined for spawning or reproductive state. Fish not identified in the field were preserved in 10% formalin and sent to TI's biological processing laboratory.

Seines. Beach seining using a 3-millimeter mesh seine and comprising three hauls per sample was conducted 11 times each at Ohio River miles 705, 707, 717, and 722. The same technique was used at five locations among the on-site streams once each month during August 1979 and April through July 1980. Fish collected were processed as above and released or preserved as appropriate.

Electrofishing. Electrofishing was conducted for one-half hour on 11 occasions each at Ohio River miles 705, 707, 715, 717, and 722, and the mouth of Town Creek. Stunned fish were captured by dip net, placed in a tub, and processed as above.

Fish Eggs and Larvae. Fish eggs and larvae were sampled at Ohio River miles 705, 707, 715, 717, and 722 weekly (30 times) during summer 1979 and spring 1980 sampling periods. Samples were collected using a 0.5-meter-diameter, 2.5-meter-long, 505-micrometer-mesh plankton net. For each sample, the net was towed upstream at 1 meter per second for 5 minutes at the surface and bottom at two near-from-shore locations on a transect perpendicular to the shore. At the surface of a nearshore location a single tow was made in the same manner as described above. The net was equipped with a General Oceanics Model 2030 flowmeter for measuring volume of water sampled. Samples were emptied from a removable bucket into 1-liter polyethylene containers, preserved with 5% buffered formalin, and sent to Dallas for analysis.

5.8.2.1.2 Field Quality Control/Quality Assurance

Nets for collecting fish samples were examined regularly for tears and repaired or replaced as necessary. The plankton net flowmeter and electrofishing equipment were tested prior to each sampling effort. Field personnel responsible for fish identification had exhibited ability to perform fish sample analysis and were provided with appropriate taxonomic keys. Any questionable identification was sent to Dallas for verification, as were individuals too small to identify in the field. Voucher specimens were retained.

Sample/Data Progress Sheets, as described in Subsection 5.8.1.2, were used for all biological samples as well as water quality samples. Those completed in the field were copied and sent to Dallas along with those to be completed in the laboratory. Samples received were inventoried and logged in through the progress sheets. The sheets were copied and the original placed in a binder to serve as a ledger to mark processing progress. Laboratory-completed sheets and field-completed sheets were checked for completeness and accuracy of data codes.

5.8.2.1.3 Laboratory Procedure

Fish egg and larvae samples were stained with rose bengal dye, washed in a 63-micrometer-mesh seive, sorted, and identified. Before sorting, dense samples were split to a minimum of 100 organisms per liter using a Folsom-type splitter. Sorted individuals were put in vials containing 70% alcohol. The samples were retained until quality checks were completed.

5.8.2.1.4 Laboratory Quality Assurance/Quality Control

TI's biological laboratory QA/QC procedures for identification focus on program-specific samples. All taxa initially identified were confirmed by the task supervisor. The supervisor then spotchecked all subsequent samples to insure an acceptable level of accuracy. Assistance also was provided as needed. Pertinent literature was available and personnel could identify and request additional assistance. A voucher collection was maintained.

Additionally, on a routine basis, duplicate analysis of sorting and identification was performed on one sample per set or 5% of a sample set comprising more than 20 samples. QA/QC failure was considered to occur when incorrect identification or variation in counted or sorted total numbers was outside the statistically determined range of normal variance. All samples analyzed by an individual that failed QC were reprocessed.

Entries on data sheets were checked for accuracy at the rate of 10% per sample set and all sheets were checked for completeness. The sheets were then given to the program administrator for transmittal to the data center for computerization or to the program manager. Computerized data were checked through computer audit procedures and tables generated were checked at the rate of 10% per sample set.

5.8.2.2 Benthos

5.8.2.2.1 Field Procedure

Benthic fauna of the study area were surveyed using three sampling techniques. A forth technique was used especially to sample mussels in the Ohio River.

Mussels. Mussels were sampled using a crowfoot bar dredge appartus during July, August, and May. The July 1979 survey covered three areas: Ohio River miles 703 to 707, RM 715 to 717, and RM 721 to 722. The August 1979 and May 1980 surveys were in generally the same areas, except the May survey began at RM 702 to include the area within Kentucky Utilities revised boundaries on the Breckinridge site. Prior to each survey, local persons were consulted to determine locations of former commercially harvested mussel beds. The surveys yielded no live mussels.

Ponar Dredge. Benthos was sampled using a 530-square-centimeter ponar dredge at Ohio River miles 705, 715, 717, and 722 once during June, July, September, and December 1979, and April 1980. The samples were washed in a 595-micrometer (no. 30) mesh screened bucket, placed in a 1-liter polyethylene container with 10% formalin, and sent to Dallas.

Ekman Dredge. Benthos of the onsite streams was sampled using a 6- x 6-inch Ekman dredge during September and December 1979 and April and July 1980. The samples were treated like those collected from the river.

Drift Net. Twenty hours prior to Ekman dredge sampling, drift net samples of 1-hour duration were collected approximately 50 meters downstream from the Ekman dredge station. The net had 505-micrometer-mesh netting, a 0.1-square-meter mouth, and a 0.5-meter length. The height and velocity of water passing through the net were measured when the net was set and when the sample was retrieved. The samples were placed in a 1-liter polyethylene container with 10% formalin and sent to Dallas.

5.8.2.2.2 Field Quality Assurance/Quality Cont[illegible]

QA/QC procedures for handling benthos samples were the same as described for other aquatic samples.

5.8.2.2.3 Laboratory Procedure

Benthos samples were washed in a 595-micrometer-mesh sieve, sorted, and identified. No benthos samples were split; otherwise, the sorting, identifying, and storage procedure followed that for fish eggs and larvae.

5.8.2.2.4 Laboratory Quality Assurance/Quality Control

TI's biological laboratory standard QA/QC procedures were followed (Subsection 5.8.2.1.4).

5.8.2.3 Macroplankton

One set of fish eggs and larvae samples collected during June, July, and August 1979 and April and May 1980 was analyzed for macroplankton as well as fish. These samples were premarked for dual analysis. For macroplankton analysis, laboratory procedures included washing in a 63-micrometer-mesh sieve, sorting, and identification. Dense samples were split in the same manner as fish eggs and larvae samples. All standard biological laboratory procedures discussed above were followed.

5.9 THREATENED AND ENDANGERED SPECIES

Prior to conducting fish, wildlife, and vegetation surveys on the sites and adjacent protions of the Ohio River, threatened and endangered species potentially occurring in the project area were determined and their possible habitats identified. Contacts for determining potential presence of threatened and endangered species or those proposed for either status included Fish and Wildlife Service, Region IV in Atlanta, Georgia, and the Kentucky Nature Preserves Commission in Frankfort, Kentucky. FWS identified proposed threatened or endangered plant species potentially occurring in the project area (Milstead, personal communication 1978). The Kentucky Nature Preserves Commission searched their data files for records of these plant species, as well as for records of listed or proposed threatened or endangered animal species potentially occurring in the project area. There were no records of any Federally listed proposed plant or animal species in the project area (TI visit to the Commission, 1979).

During on-site sampling in spring, summer, and fall, appropriatae habitats for proposed or listed species were searched for and any found were surveyed for species presence. No Federally listed species were found during these special searches nor during regular sampling. Several fish and wildlife species on the Kentucky Nature Preserves Commission Plant and Animal List were observed, as discussed Sections 3.3 and 3.5.

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SUPPLEMENTS

The results of three air quality studies conducted by Willamette Industries, Kentucky Utilities, and Normandeau Associates, Inc. are presented as Supplements A, B, and C, respectively. As mentioned in Section 2.5, these analyses were conducted to determine the potential impact of Kentucky Utilities' coal handling and storage activities on Willamette's bleached pulp production. A summary of the methodologies of each study and a summary of the NAI study were presented in Technical Appendix Sections 2.5 and 4.2 and in the Draft Environmental Impact Statement.

SUPPLEMENT A

WILLAMETTE INDUSTRIES' FUGITIVE EMMISSIONS IMPACT ANALYSIS

Willamette Industries, Inc.

Executive Offices

3800 First National Bank Tower
Portland Oregon 97201
503/227-5581

May 29, 1981

Ms. Rebecca W. Hanmer
Regional Administrator
United States Environmental
Protection Agency
Region IV
345 Courtland Street, N. E.
Atlanta, Georgia 30308

Subject: Kentucky Utilities Company ("KU") - Environmental Impact Statement

Dear Ms. Hanmer:

In my May 6, 1981, letter to you I referred to an EPA request for information concerning potential contamination to Willamette's Hawesville, Kentucky operations by coal dust from the proposed KU power plant. Enclosed is a report on the potential for contamination, that was prepared with the assistance of our environmental consultants, Kenvirons, Incorporated.

We are pleased that the EPA has requested this report! For it is recognition that the contamination impact of our operations is within the scope of your permitting process and can be grounds for denial of both the PSD and EIS permits.

The report confirms and quantifies the contamination that the KU project will cause our bleached pulp and fine paper operations. However, it is very conservative in its analysis and assumptions. For example, in evaluating the extent and frequency of contamination, no assessment is made of the impact of reentrainment of coal dust. We have also limited the assessment to the visible size range of 15-25 mm. This impact does not consider expected downgrading for "brightness" caused by smaller size coal dust particles. "Brightness" is a critical specification for the marketability of our pulp. The analysis also does not consider the anticipated growth of the chip pile to accommodate increased production rates, which are projected to reach 725 tons per day by 1984. In fact, the conservative approach considers only that the coal dust will fall on about one-fourth of the total chip pile.

Even with such a conservative approach, the impact of less than 1.0 ug/m^3 of coal dust in the air will cause our product to be "off-grade." The frequency of such impacts and their unpredictable character would force us out of our current bleached pulp and fine paper markets.

We consider the KU contamination to be an environmental impact. We also anticipate that when the EPA eventually obtains sufficient information on KU's project to allow a complete analysis of the air impact, the EPA will conclude that the project will violate NAAQS for TSP.

We appreciate that the EPA must also consider BACT and that BACT analysis includes economic considerations. Apparently, in recognition of this obligation, Mr. Robert Howard and Mr. Dario Dal Santo asked us to provide an economic evaluation of KU's air contamination. Such an evaluation is very difficult because the KU facility is not scheduled for operation until 1989 and, of course, 1989 pulp prices and our own production are unknowns. What we do know is that KU air contamination will cause our pulp to go off-grade. We also know that we presently have no market for off-grade pulp. Consequently, one economic impact of the KU contamination will be loss of 430 tons/day sold at 1981 prices of $435 per ton, for a daily revenue loss exceeding $187,000.

It is worth noting that if we are forced to curtail operations, the economic impact would spread to our raw materials suppliers, especially those who furnish chips.

To date, we have not received from EPA, Normandeau Associates or KU any information which is contrary to the conclusions expressed in the attached report. If EPA has any such information, we request the opportunity to review it.

If you have any questions about the enclosed report, we would be pleased to meet and discuss it.

Very truly yours,

WILLAMETTE INDUSTRIES, INC.

Steven R Rogel

Steven R. Rogel,
Vice President - Paper Group

SRR:jm

cc: Ms. Jackie Swigart
Judge James Fallin
Normandeau Associates, Inc.
Attn: Ms. Audrey James
Mr. Alec Little
Mr. John Hagan
Mr. Tom Devine
Mr. Bob Howard
Mr. Dario Dal Santo
Mr. Terry Siemsen

Willamette Industries, Inc.

Executive Offices

3800 First National Bank Tower
Portland, Oregon 97201
503 227 5581

June 2, 1981

Ms. Rebecca W. Hanmer
Regional Administrator
United States Environmental
  Protection Agency
Region IV
345 Courtland Street, N. E.
Atlanta, Georgia 30365

Subject: Kentucky Utilities Company
("KU") - Environmental
Impact Statement

Dear Ms. Hanmer:

Enclosed is a revised copy of the report on contamination of our Hawesville, Kentucky properties by the proposed KU project. We have also enclosed marked copies of original pages 5, 12 and 13 so that the revisions can be easily located. You will note that the date has been changed to June 1, 1981, which is the date we identified the errors in the report submitted to you on May 29, 1981.

Although the corrections do not change the conclusions reached in the report, we think it will serve to avoid confusion if you destroy the earlier report.

Very truly yours,

Steven R. Rogel

Steven R. Rogel
Vice President - Paper Group

SRR:jm
Enc.

cc: Ms. Jackie Swigart
Judge James Fallin
Normandeau Associates, Inc.
  Attn: Ms. Audrey James
Mr. Alec Little
Mr. John Hagan
Mr. Tom Devine
Mr. Robert Howard
Mr. Dario Dal Santo
Mr. Terry Siemsen

June 1, 1981

CONTAMINATION BY COAL DUST FROM THE PROPOSED KU POWER PLANT

This report is in two parts. The first concerns the bleached pulp operation. Only two areas of this operation are assessed for contamination input -- the chip pile and the pulp dryer. The chip pile is the storage area for hardwood chips which are the basic material from which the pulp fibers are separated. The bleached pulp dryer removes water from the pulp which has been added during the various phases of operation which convert the hardwood chips into bleached pulp suitable for fine grades of paper. The second part of the report considers the new fine paper operations scheduled for start-up in December, 1981.

POTENTIAL CONTAMINATION FROM THE PROPOSED KU POWER PLANT ON THE BLEACHED PULP MILL OF WILLAMETTE INDUSTRIES, INC.

I. Data and Assumptions

The major impact of the proposed KU Hancock Power Plant on Willamette will be from fugitive emissions of coal dust. Of these fugitive emissions, the coal dust with a particle size of 15-25 μm will have the greatest impact because this size is easily visible and will be included in the pulp and paper industry dirt count determination. In addition, this particle size is sufficiently small to be transported the 1.5-mile distance from major sources such as the coal pile to the chip pile by relatively low local wind speeds.

There are several points along the pulping and bleaching process at which the pulp could be contaminated by coal dust. The greatest points of contamination, however, will be the chip pile and pulp dryer.

The bleached pulp plant has two chip piles which are aligned in a North-South direction. These two piles contain approximately 100,000 tons of chips which are sufficient for approximately 50 days of plant operation. The chips are used on a "first-in, first-out" basis; thus the piles are cycled approximately every 50 days. These two chip piles currently cover about 5.4 acres, each being similar in size. However, for the assessment of impact we have chosen to be very conservative and have only considered that portion of the chips which would be directly facing the KU operation. The southern facial area of the south chip pile is estimated to be 1.19 acres or 4815.8 square meters. Based upon the size of this portion of the chip piles, the bleached pulp operations will be significantly impacted from chip contamination every 50 days for a period of 10 days.

In order to determine the frequency of occurrence, it was necessary to evaluate the meteorological conditions necessary for coal dust transport. Again being conservative, we have determined and assessed the impacts based upon direct transport of particles from their original emission points. We have not included the greatest impact -- the reentrainment of fallen coal dust from throughout the property and "re-emitted" due to vehicular traffic and localized wind action.

The wind velocities necessary for transport have been determined based upon calculations using Stokes Law of falling particles. In order to use this law, it was necessary that several assumptions be made:

1. We have assumed that the average distance of the coal fugitive sources is 8,000 feet (approximately 1.5 miles). This distance was taken from the layout drawing recently furnished by EPA.

2. We have assumed that the average emitted coal particle size is 20 μm and has a specific gravity of 1.35. This is based upon information from "Survey of Fugitive Dust From Coal Mines," EPA 908/1-78-003 and verbal conversation with the Kentucky Coal Association for specific gravity of Western Kentucky Coal.

3. It is also necessary to determine a height of release in relationship to the height of impact. The height of release is assumed to be between 30 and 50 feet, and the height of impact is assumed to be ground level since the chip pile is worked to the ground and the air intake for the dryer is at ground level. It should also be noted that there is a ground elevation difference between the source and receptor. The coal fugitive sources are at a ground elevation of approximately 425 feet MSL, whereas the chip pile has a ground elevation of 412 feet. This results in an average elevation difference of 53 feet.

4. A further assumption is the removal efficiency of coal dust from the pulping, bleaching and cleaning process.

This removal efficiency is much lower than for common dirt due to the similar specific gravities of pulp and coal. The pulp has a specific gravity of 1.2 to 1.3 and coal, as previously noted, has a specific gravity of 1.35. The cleaning device used by Willamette is a C. E. Bauer Model 606-110P Centri-Cleaner. According to the manufacturer, the estimated efficiency will be in the 75-85 percent range, depending upon operating conditions and particle size. The overall plant removal efficiency is then estimated to be 85 percent of coal from the chip pile.

5. With respect to the pulp dryer, it is estimated that 75 percent of the coal dust passing through the dryer will be collected on the pulp mats.

6. Finally, it should be noted that, at present, the production rate of pulp is 430 tons of pulp product per day or 2,000 ft^2 of pulp mats per minute. In addition, 3.25 tons of chips are required per ton of pulp product. Pulp production is scheduled to increase to 615 tons per day, in order to supply the new fine paper machine, and will reach a projected 700 tons per day by 1984.

II. Assessment of Contamination

Based upon the above-listed data and assumptions, we assessed the impact of various given concentrations ($\mu g/m^3$) of coal dust at the bleached pulp plant. All calculations are shown in Attachment I.

As previously mentioned, the first step is to determine meteorological conditions necessary for transport using Stokes Law. Using the above assumptions and data, the wind speed necessary for complete transport is 5.47 MPH.

Based upon meteorological data collected by Willamette on-site, near where the coal pile will be located, winds from the East-Southeast through winds from the South-Southeast exceed 5.47 MPH, approximately 6 percent of the hourly observations. Thus, 525 hours per year could result in visible particles directly from the KU coal-handling facilities contaminating the bleached pulp operations.

A. Contamination at Chip Pile

Based upon the 50-day chip cycle, the high impact chip area would be processed 7.3 times per year and, on the average, would have received 72 hours of contaminating winds during the 50-day cycle.

Using the 5.47 MPH wind speed and a concentration of 1.0 $\mu g/m^3$, we find that during each second 2.45 $\mu g/m^2$ of coal dust will be deposited. Therefore, the south face of the southern chip pile will receive 42.47 grams per hour, and, during the 50-day chip cycle, this area will receive 3,058 grams (approximately 7 pounds) of coal dust.

Based upon the assumed particle size and density, this 3,058 grams will represent 5.41×10^{11} visible particles. Due to settling in the chip pile, these particles will be dispersed throughout the impacted face of the southern pile, which contains 22,037 tons of chips. Since it take 3.25 tons of chips per ton of pulp product, the coal dust in the chip pile will contaminate 6,781 tons of pulp product or 45.2 million ft^2 of pulp mats. Based upon the 85 percent removal efficiency for coal dust, the amount of coal dust reaching the finished product is 8.12×10^{10} particles. This level of contamination is equal to 1,796 particles/ft^2 of pulp mat or a contamination density of 6.07 mm^2/m^2.

Therefore, 7.3 times per year for 10 days based upon a concentration of 1.0 $\mu g/m^3$ of coal dust coming from the KU operation, a contamination level of 6.07 mm^2/m^2 in the form of coal dust will be added to the existing background contaminations. As shown by Table I, even a relatively low concentration of coal dust at one entry point, at the chip pile, will cause the pulp to be off-grade.

B. Contamination at Bleached Pulp Dryer

As previously mentioned, the other major area of potential coal dust contamination is the dryer. Based upon a uniform distribution and a concentration of 1.0 $\mu g/m^3$, the number of particles per ft^3 of air is 5.01. Since the amount of pulp dryer make-up air is 35,000 cfm, the number of particles entering the dryer per minute is 0.175 million. Since 75 percent of the particles will be deposited on the pulp mats, then this level will represent 65.8 particles per ft^2 or a contamination density of 0.222 mm^2/m^2.

This contamination at the dryer would occur each time the bleach plant was downwind of the KU coal-handling operations, which as previously discussed, is estimated to be

525 hours per year. Of course, 1/5 of these hours will be associated with periods when the southeast face of the southern chip pile is being consumed (105 hours). Thus, we see that 420 hours per year will be a dryer impact only. During each of these chip contamination periods (7.3 times per year), on the average, 14 hours will occur when there is both chip pile and dryer contamination due to coal dust from the KU facility.

Based on data from the previous 12 months, the average background dirt count in the finished bleached pulp is 1.94 mm^2/m^2. Therefore, based upon 1.0 $\mu g/m^3$ of coal dust contamination, during periods of contamination only from the chip pile, the dirt count is 8.01 mm^2/m^2. During periods of straight dryer contamination, the total dirt count will be 2.16 mm^2/m^2. When there is both chip pile and dryer contamination, the total dirt count will reach 8.23 mm^2/m^2.

Tables I - II show the minimum coal dust particulate concentration which will result in degrading of the pulp product. These levels of coal dust contamination were determined by proportioning to the values given for a 1.0 $\mu g/m^3$ concentration.

Again, it should be noted that this is a conservatively estimated impact, since we have considered limited points of contamination and have not considered the impact due to reentrainment of coal dust.

TABLE I

CONCENTRATIONS OF VISIBLE COAL DUST THAT WILL DEGRADE THE PULP PRODUCT FROM CONTAMINATION AT THE CHIP PILE ONLY*

Concentration of Visible Coal Dust (ug/m^3)	Coal Dust Contamination	Background (Existing level) of Pulp Contamination	Total Contamination	Grade Level
0.0 ug/m^3	0.0 mm^2/m^2	1.94 mm^2/m^2	1.94 mm^2/m^2	Number One Prime
0.2 ug/m^3	1.21 mm^2/m^2	1.94 mm^2/m^2	3.15 mm^2/m^2	Number Two Prime
0.9 ug/m^3	5.46 mm^2/m^2	1.94 mm^2/m^2	7.40 mm^2/m^2	Off-Grade
1.4 ug/m^3	8.50 mm^2/m^2	1.94 mm^2/m^2	10.44 mm^2/m^2	
4.0 ug/m^3	24.28 mm^2/m^2	1.94 mm^2/m^2	26.22 mm^2/m^2	
10.0 ug/m^3	60.70 mm^2/m^2	1.94 mm^2/m^2	62.64 mm^2/m^2	

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*Predicted to occur for 10 consecutive days, 7.3 times per year or a total of 73 days.

TABLE II

CONCENTRATIONS OF VISIBLE COAL DUST THAT WILL DEGRADE THE PULP PRODUCT FROM CONTAMINATION AT THE THERMAL DRYER ONLY*

Concentration of Visible Coal Dust (ug/m^3)	Coal Dust Contamination	Background (Existing level) of Pulp Contamination	Total Contamination	Grade Level
0.0 $\mu g/m^3$	0.0 mm^2/m^2	1.94 mm^2/m^2	1.94 mm^2/m^2	Number One Prime
4.9 $\mu g/m^3$	1.09 mm^2/m^2	1.94 mm^2/m^2	3.03 mm^2/m^2	Number Two Prime
22.9 $\mu g/m^3$	5.08 mm^2/m^2	1.94 mm^2/m^2	7.02 mm^2/m^2	Off-Grade

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*Predicted to occur 420 hours per year.

TABLE III

CONCENTRATIONS OF VISIBLE COAL DUST THAT WILL DEGRADE THE PULP PRODUCT FROM CONTAMINATION AT BOTH THE CHIP PILE AND THE THERMAL DRYER*

Concentration of Visible Coal Dust (ug/m^3)	Coal Dust Contamination	Background (Existing level) of Pulp Contamination	Total Contamination	Grade Level
0.0 ug/m^3	0.0 mm^2/m^2	1.94 mm^2/m^2	1.94 mm^2/m^2	Number One Prime
0.2 ug/m^3	1.26 mm^2/m^2	1.94 mm^2/m^2	3.20 mm^2/m^2	Number Two Prime
0.9 ug/m^3	5.66 mm^2/m^2	1.94 mm^2/m^2	7.60 mm^2/m^2	Off-Grade
1.3 ug/m^3	8.18 mm^2/m^2	1.94 mm^2/m^2	10.12 mm^2/m^2	
4.0 ug/m^3	25.16 mm^2/m^2	1.94 mm^2/m^2	27.10 mm^2/m^2	
10.0 ug/m^3	62.90 mm^2/m^2	1.94 mm^2/m^2	64.84 mm^2/m^2	

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*Predicted to occur 105 hours per year.

ATTACHMENT I

CALCULATIONS OF CONTAMINATION ON BLEACHED PULP PLANT

WIND NECESSARY FOR TRANSPORT -

Stokes Law

$$c = \frac{2r^2g}{9} \times \frac{S_1-S_2}{n}$$

Where: c = Velocity (cm/sec)
r = radius of particle (cm)
g = 981 cm/sec^2 (acceleration)
S_1 = Density of particle
S_2 = Density of air
n = Viscosity of air (1814 X 10^{-7} poises)

$$c = \frac{2\ (.001)^2\ 981}{9} \times \frac{1.35}{1814 \times 10^{-7}} = 1.622 \text{ cm/sec}$$

Settling Velocity = 97.34 cm/min or 3.19 feet/min.

Elevation difference equals = 53 ft.
Necessary transport time equals = 53 ft./3.19 ft/min = 16.61 min.

Transport distance equals 8000 ft.

Necessary transport wind equals - 8000 ft./16.61 min. = 482 ft./min. or 5.47 MPH

Number of chip pile cycles per year = 365/50 = 7.3

Number of hours of contamination equals = 525/7.3 = 72.

AMOUNT OF COAL DUST DEPOSITED ON CHIP PILE PER HOUR -

Coal Dust Contamination = 1.0 μg/m^3

Wind Speed = 5.47 MPH or 2.45 meter/second

Amount deposited/second = 1.0 μg/m^3 X 2.45 meter/second = 2.45 μg/m^2/sec
Amount deposited on chip pile/second = 2.45 μg/m^2/sec X 4815.8 m^2 = 11,798 μg/second

Amount deposited on chip pile/hour = 11,798 μg/sec X 3600 sec/hour = 42.47 gm/hr

NUMBER PARTICLES ENTERING DRYER PER MINUTE -

5.01 particles/ft^3 X 35,000 cfm = 0.175 million

Concentration of contamination at dryer

0.75 X 0.175 million particles/min divided by 2000 ft^2 pulp mat/min =

= 65.8 particles/ft^2 pulp mat

= 65.8 particles/ft^2 X $\frac{10.764\ ft^2}{m^2}$

= 708. particles per m^2

Contamination density at dryer

708. particles/m^2 X 3.1416 X 10^{-10} m^2/particle =

0.222 X 10^{-6} m^2/m^2 or 0.222 mm^2/m^2

NUMBER PARTICLES PER 3058 GRAMS OF COAL DUST -

Volume of 20 µm particle equals:

$$V = \frac{4 \pi r^3}{3} = \frac{4 \pi (0.001\ cm)^3}{3} = 4.188 \times 10^{-9}\ cm^3$$

Weight per cc is 1.35 grams (specific gravity)

Weight of a 20 µm coal particle equals

4.188 X 10^{-9} cc X 1.35 grams/cc = 5.653 X 10^{-9} grams

Number of particles per 3058 grams is

3058 divided by 5.653 X 10^{-9} = 5.41 X 10^{11}

AMOUNT OF PARTICLES PER FT^2 OF PULP MATS -

Tons of chips in 1.19 acres equals

100,000 tons total chips/5.4 acres X 1.19 acres = 22037 tons

Tons of pulp produced by 22037 tons of chips 22037/3.25 = 6781 ton of pulp product.

One square foot of pulp mats weighs about 5 oz. or 0.3 pounds.

5788 tons of pulp product is approximately 45.2 million ft^2

6781 tons X $\frac{2000 \text{ lb}}{\text{ton}}$ / 0. 3 lb/ft^2 = 45.2 million ft^2

Amount of coal dust reaching finished product from chip pile

8.12 X 10^{10} particles

5.41 X 10^{11} X $\frac{100\% - 85\%}{100\%}$ = 8.12 X 10^{10} particles

Amount of coal particle per ft^2 of pulp mat from chip pile

8.12 X 10^{10} particles/45.2 million ft^2 of pulp mats = 1796 particle/ft^2

AREA OCCUPIED BY ONE COAL DUST PARTICLE -

Radius of particle is 10 X 10^{-6} meters

area = πr^2 = 3.1416 X $(10 \times 10^{-6})^2$ = 3.1416 X 10^{-10}m^2

Area of one particle is 3.1416 X 10^{-10}m^2

Number of particle per meter^2 -

1796 particle/ft^2 X $\frac{10.764 \text{ ft}^2}{\text{meter}^2}$ = 19,332 particles/m^2

AREA OCCUPIED BY 19,332 PARTICLES PER M^2 PULP MAT -

19332 part/m^2 X 3.1416 X 10^{-10}m^2/part = 6.07 X 10^{-6} m^2/m^2 or 6.07 mm^2/m^2

NUMBER OF PARTICLES PER FT^3 OF AIR AT A CONCENTRATION OF 1 μg/m^3 -

1 μg/m^3 X $\frac{0.028317 \text{ m}^3}{\text{ft}^3}$ = 0.028317 μg/ft^3

Weight of one 20 μm coal dust particle is 5.663 X 10^{-9} grams

or 5.653 X 10^{-3} μg per particle of coal dust

0.028317 μg/ft^3 divided by 5.653 X 10^{-3} μg/particle = 5.01 particle/ft^3

CONTAMINATION FROM KU POWER PLANT ON THE FINE PAPER OF WILLAMETTE INDUSTRIES, INC.

I. Data and Assumptions

Willamette plans initially to produce 185 tons of bleached pulp per day for use in its fine paper machine. This pulp will not be dried, but will be pumped to the paper plant directly and combined there with other pulps of different fibers.

With respect to the coal dust particle size, density and meteorological conditions necessary for contamination, the same data and assumptions made for the bleached plant operation will be used for this assessment. However, in addition to the previous information given, it is important to note that: (1) the make-up air for the fine paper machine building is 360,000 cfm, (2) 285 tons/day of paper is produced, which is equal to approximately 12,600 ft^2 of paper per minute, and (3) it is assumed that 75 percent of the particles entering the fine paper machine building will fall upon the paper as it is produced.

II. Assessment of Contamination

Based upon the above data and assumptions, we assessed various given concentrations ($\mu g/m^3$) of coal dust on the fine paper. Calculations specific to the fine paper machine building are shown in Attachment II.

As previously determined, the number of particles per ft^3 of air of a concentration of 1.0 $\mu g/m^3$ is 5.01. Therefore, 1.8 million visible coal dust particles will be entering the fine paper machine building per minute. Based upon the 12,600 ft^2/min. of paper production and a 75 percent settlement on the paper, the contamination would be 107 visible particles per ft^2 of paper, which is equivalent to a dirt count of 0.361 mm^2/m^2. Therefore, when the fine paper machine building is downwind of the KU coal-handling facilities, 0.361 mm^2/m^2 of coal dust is deposited on the paper, based upon an air concentration of 1.0 $\mu g/m^3$. Again, based upon the previous assumptions, this will occur 6 percent of the time or 525 hours per year.

The major source of contamination will be in the pulp itself. Since 75 percent of the paper produced by the paper machine will contain pulp generated at the Hawesville bleached pulp plant, significant contamination will occur wherever the contaminated pulp is used. In many cases the pulp will be so highly contaminated that it will be necessary to try to replace it with pulp purchased elsewhere. As previously discussed, the frequency with which this will occur is approximately every 50 days for a period of 10 consecutive days or 73 days per year.

During those days on which the contaminated chip pile is being processed, but the wind is not blowing from KU, the contamination from coal dust is 4.55 mm^2/m^2. During those days on which the contaminated chip pile is being processed and the wind is blowing from KU, the contamination from coal dust is 5.08 mm^2/m^2. Finally, on those days on which the contaminated chip pile is not being processed and the wind is blowing from KU, the contamination from coal dust is 0.528 mm^2/m^2. All the above dirt counts were based upon a visible coal dust concentration of 1.0 $\mu g/m^3$.

Tables I - III give the minimum coal dust particulate concentrations which will result in degrading of paper product. The levels of coal dust concentration were determined by proportioning the contamination given above for a 1.0 $\mu g/m^3$ concentration.

Finally, just as with the assessment of impacts on the pulp mill and bleached plant, this is a conservative estimate, since we have considered limited points of contamination and have not considered the impact due to reentrainment of coal dust.

TABLE I

CONCENTRATION OF VISIBLE COAL DUST THAT WILL DEGRADE THE FINE PAPER MADE FROM PULP CONTAMINATED AT CHIP WHEN WINDS FROM KU FACILITY*

Concentration of Visible Coal Dust	Coal Dust Contamination	Assumed Background Level of Fine Paper Contamination	Total Contamination	Grade Level
0.0 $\mu g/m^3$	0.0 mm^2/m^2	0.5 mm^2/m^2	0.5 mm^2/m^2	Acceptable
0.4 $\mu g/m^3$	2.03 mm^2/m^2	0.5 mm^2/m^2	2.53 mm^2/m^2	Off Grade For Envelopes
0.6 $\mu g/m^3$	3.05 mm^2/m^2	0.5 mm^2/m^2	3.55 mm^2/m^2	Off Grade for Fine Paper
1.0 $\mu g/m^3$	5.08 mm^2/m^2	0.5 mm^2/m^2	5.58 mm^2/m^2	
4.0 $\mu g/m^3$	20.32 mm^2/m^2	0.5 mm^2/m^2	20.82 mm^2/m^2	

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*Predicted to occur 105 hours per year.

TABLE II

CONCENTRATION OF COAL DUST THAT WILL DEGRADE THE FINE PAPER MADE FROM CONTAMINATED PULP FROM CHIP PILE AND WINDS NOT FROM THE KU FACILITY*

Concentration of Visible Coal Dust	Coal Dust Contamination	Assumed Background Level of Fine Paper Contamination	Total Contamination	Grade Level
0.0 $\mu g/m^3$	0.0 mm^2/m^2	0.5 mm^2/m^2	0.5 mm^2/m^2	Acceptable
0.4 $\mu g/m^3$	1.82 mm^2/m^2	0.5 mm^2/m^2	2.32 mm^2/m^2	Off Grade For Envelopes
0.7 $\mu g/m^3$	3.18 mm^2/m^2	0.5 mm^2/m^2	3.68 mm^2/m^2	Off Grade for Fine Paper
1.0 $\mu g/m^3$	4.55 mm^2/m^2	0.5 mm^2/m^2	5.05 mm^2/m^2	
4.0 $\mu g/m$	18.20 mm^2/m^2	0.5 mm^2/m^2	18.70 mm^2/m^2	

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*Predicted to occur 73 days per year.

TABLE III

CONCENTRATION OF VISIBLE COAL DUST THAT WILL DEGRADE
THE FINE PAPER MADE FROM UNCONTAMINATED PULP
BUT WINDS FROM THE KU FACILITY*

Concentration of Visible Coal Dust	Coal Dust Contamination	Assumed Background Level of Fine Paper Contamination	Total Contamination	Grade Level
0.0 $\mu g/m^3$	0.0 mm^2/m^2	0.5 mm^2/m^2	0.5 mm^2/m^2	Acceptable
3.5 $\mu g/m^3$	1.85 mm^2/m^2	0.5 mm^2/m^2	2.35 mm^2/m^2	Off Grade For Envelopes
5.6 $\mu g/m^3$	2.96 mm^2/m^2	0.5 mm^2/m^2	3.46 mm^2/m^2	Off Grade for Fine Paper
10.0 $\mu g/m^3$	5.28 mm^2/m^2	0.5 mm^2/m^2	5.28 mm^2/m^2	

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*Predicted to occur 420 hours per year.

ATTACHMENT II

CALCULATIONS OF IMPACT ON FINE PAPER FROM KU POWER PLANT

NUMBER OF COAL DUST PARTICLES ENTERING FINE PAPER MACHINE BUILDING PER MINUTE AT 1.0 $\mu g/m^3$ -

5.01 particles/ft^3 X 360,000 ft^3 min = 1.8 million

NUMBER OF COAL DUST PARTICLES PER FT^3 OF PAPER -

Number of ft^2 of paper produced per minute equals 12,600 ft^2

0.75 X 1.8 million visible particles/12,600 ft^2 of paper = 107. visible particles/ft^2 of paper

DIRT COUNT OR DENSITY REPRESENTED BY 107 VISIBLE PARTICLES/FT^2 -

107 particles/ft^2 = 107 X 10.764 ft^2/m^2 = 1152 particles/$meter^2$ area of one particle equals 3.1416 X 10^{-10} m^2/particle

1152 particles/m^2 X 3.1416 X 10^{-10} m^2/particle = 0.361 mm^2/m^2

CONTAMINATION DURING PROCESSING OF CONTAMINATED CHIP PILE WHEN THE WIND IS NOT BLOWING FROM KU -

6.07 mm^2/m^2 X 0.75 = 4.55 mm^2/m^2

CONTAMINATION DURING PROCESSING OF CONTAMINATED CHIP PILE WHEN THE WIND IS BLOWING FROM KU -

(6.07 mm^2/m^2 + 0.222 mm^2/m^2) X 0.75 + 0.361 mm^2/m^2 = 5.08 mm^2/m^2

CONTAMINATION WHEN THE WIND IS BLOWING FROM KU, BUT THE CONTAMINATED CHIP PILE IS NOT BEING PROCESSED -

(0.222 mm^2/m^2) X 0.75 + 0.361 mm^2/m^2 = 0.528 mm^2/m^2

SUPPLEMENT B

KENTUCKY UTILITIES' FUGITIVE EMISSIONS IMPACT ANALYSIS

July 10, 1981

ATTACHMENT 1

COMMENTS ON WILLAMETTE INDUSTRIES DISCUSSION OF CONTAMINATION BY COAL DUST FROM THE PROPOSED KU POWER PLANT SUBMITTED TO EPA ON JUNE 2, 1981

Introduction

By letter dated May 29, 1981, Willamette Industries, Inc., submitted to the U.S. EPA a statement concerning alleged effects of Kentucky Utilities Company's (KU) proposed Hancock power plant on Willamette's Hawesville pulp and paper facility. On June 2, 1981, a revised report was submitted which corrected errors contained in the original report. Pursuant to KU's request, Sargent & Lundy has reviewed Willamette's revised statement. Although sufficient time has not been available to analyze and respond fully to all aspects of this statement, it clearly contains erroneous procedures and misleading information which should be brought to the U.S. EPA's attention at this time. Further comments may be appropriate during the normal environmental impact statement comment period.

The Willamette statement consists of two components. First, it attempts to predict the amount of coal particles that will be deposited on the Western Kraft wood chip pile as a result of the coal handling operation at the Hancock plant. The second part purports to analyze the effect of coal particles in the wood chip pile and in the ambient air on their final products. This part involves the details of the plant's operations and detailed analysis and comment was not possible within the time

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constraint requested by the agency. Therefore, this report is confined to a discussion of the lack of valid scientific basis for Willamette's prediction of coal particle deposition on the Western Kraft wood chip pile, and a few general observations concerning the other aspects of Willamette's statement.

Coal Particle Deposition

The Willamette analysis contains several erroneous assumptions that completely invalidate the conclusions regarding the amount of coal particle deposition on the wood chip pile.

First, Willamette assumes that the ambient concentration of coal particles near the wood chip pile is only related to wind speed, distance between the piles, difference in elevation between the piles, and settling velocity as defined by Stoke's Law. The analysis implicitly assumes that coal particles will reach the wood chip pile only when the wind speed is sufficient to convey the particles the distance between the piles in the time required for the particles to drop the difference in elevation between the coal pile and the wood chip pile based on the settling velocity as defined by Stoke's Law. Although this assumption sounds reasonable and would be reasonable in a laboratory situation, it does not accurately represent the dynamic forces that affect the transport of coal particles over the 2.6 km of variable terrain between the two piles. To account for these factors, the EPA has developed computer models that consider several complex meteorological relationships in predicting ambient concentrations of particulate matter. The Sargent & Lundy analysis discussed in Attachment 2 uses the EPA computer model.

Willamette utilizes the mechanics of Stoke's Law and the wind speed calculations. However, the calculated wind speed is a meaningless value because ambient air concentrations and wind speed are not related in the manner assumed by Willamette. Since wind speed is not relevant in this type of analysis, the analysis of meteorological data to identify the number of hours during which the wind speed exceeded the calculated value is a meaningless exercise.

Willamette further compounds the erroneous results by assuming that deposition is a function of wind speed, concentration, and exposed surface area. This assumption includes two gross errors. First, as stated in any standard meteorological reference book (Ref. 3, for example), deposition is a function of concentration, surface area, and settling velocity - not wind speed. Second, the calculation method used by Willamette erroneously treats the wood chip pile as a perfect filter, i.e., all of the air blown toward the exposed surface of the chip pile passes through the pile and all of the coal particles in the air are collected - filtered out - by the chip pile. Again, any standard meteorological or engineering reference book (Ref. 4, for example) shows 1) that air will flow around objects, even very porous objects; a 100,000-ton wood chip pile is hardly a porous object, and 2) that very small particles will follow air flow patterns around objects. If the Willamette method were correct, the solution would be quite simple - a row of trees (evergreens for year-round protection) planted in front of the chip pile would filter the air and provide complete protection. However, the method is not correct. In fact, the procedure taken as a whole lacks any scientific basis and Willamette's prediction of coal particle deposition on the chip pile is meaningless.

Thermal Dryer

The Willamette statement also suggests that potential contamination could occur from the thermal dryer. While we cannot comment at this time on the details of the paper production process, one question on the Willamette assumptions and method of predicting contamination appears relevant. The statement assumes that all dust in the ambient air is blown over the paper pulp, and that 75% is deposited on the pulp. Willamette further claims that the current contamination level is 1.94 mm^2/m^2, and that an ambient coal dust concentration of 1.0 $\mu g/m^3$ would cause an additional dirt count of 0.222 $mm2/m^2$.

Current ambient concentration of total suspended particulate matter, as monitored in the area of the Willamette facility by the State of Kentucky, U.S. EPA, and Kentucky Utilities, ranges between 60 and 120 $\mu g/m^3$. Total suspended particulate matter in the atmosphere, as measured by the standard hi-vol sampler, is made up of a wide range of particle sizes. Though the distribution of particle sizes varies depending on the sources of particulate, a substantial fraction of the total mass is found to be contributed by particles with diameter greater than 15 μ (visible particles). Data presented by the EPA (1980) from rural areas around St. Louis indicated that approximately 40% of TSP by mass was made up of particles larger than 15 μ. For the higher concentrations measured at Hancock, where a principal component of TSP is undoubtedly rural fugitive dust, the fraction of large particles would be expected to be as great or greater.

According to the Willamette calculation method, the presently existing particulate material in the air should contribute large quantities of contamination to the pulp. If it is assumed that 40% of the ambient particulate is large enough to be visible (>15μ), the current pulp dirt count (background contamination), by the Willamette method, would be 5.3 to 10.6 mm^2/m^2. Even if only 20% of the particulates are visible in the pulp, the dirt count due to the dryer alone would exceed the current total level of background contamination. It would appear that much less than 75% of the dust particles in the ambient air actually contaminate the pulp.

Fine Paper Process

The Willamette statement also attempts to assess potential contamination of the fine paper product. However, there are apparent inconsistencies in the Willamette arguments. As in the above discussion of thermal dryer effects, if Willamette's assumptions are correct, current visible particulate matter levels in the air should produce serious contamination of the fine paper product. If Willamette's assumption that 75% of all particulate matter in the air entering the fine paper building settles on the paper is correct, and 40% of particulate matter is large enough to be visible, then current ambient levels should produce a dirt count of 9.0 to 18.1 mm^2/m^2 due to this contamination source alone. But Willamette assumes a fine paper background contamination of only 0.5 $mm^2/m2$.

Finally, Willamette calculates total contamination at the fine paper facility. In each calculation (Attachment II, Page 20 of Willamette's

Statement) they take 75% of the contamination previously calculated for the bleached pulp production. This apparently is done because it is stated that 75% of the fine paper will contain pulp from the Hawesville facility. If 75% of the pulp contamination will pass through to the fine paper, the fine paper background contamination should be higher than 0.5 mm^2/m^2 because the bleached pulp already has a background level of 1.94 mm^2/m^2. If less than 75% of the fine paper is made up of bleached pulp from Willamette's Hawesville plant, then the Attachment II calculations of Willamette's statement overstate fine paper contamination.

Also, the calculations overstate the alleged contamination because the thermal dryer contamination snould not be included in these calculations if, as stated at the top of Page 14 of Willamette's statement, bleached pulp for the fine paper machine will not be dried prior to pumping to the paper plant.

Conclusion

The method used to predict deposition on the wood chip pile although elaborate is without scientific basis and the results are meaningless. In addition, the inconsistent information presented in various parts of the statement renders the other methods used by Willamette suspect.

ATTACHMENT 2

ISC COMPUTER MODELING

Introduction

As stated in Attachment 1, deposition is primarily a function of ambient concentration, surface area and settling velocity; however, several other meteorological factors affect ambient concentrations and deposition. To account for these complex relationships, the U.S. EPA has developed and recommends for use a computer model titled, "Industrial Source Complex Short-Term (ISC-ST) Model." The ISC-ST model is the most current computer modelling technology available for predicting short-term ambient concentrations and deposition of fugitive particulates emitted from numerous sources. The ISC-ST model was used in this analysis. This model was also used in the PSD analysis.

Deposition

To ensure that the model predicted the maximum amount of coal particles that would be deposited on the Willamette wood chip pile, several steps were taken. First, five years of meteorological data were examined to select the year that would be expected to have the greatest deposition on the chip pile. Second, all coal handling and storage facilites proposed for the Hancock power plant were considered. Third, several preliminary model runs were performed with various input values for particle size and settling velocity. The parameters that would produce the highest deposition on the wood chip pile were used. Fourth, the deposition rate which is in units of grams/square meter, was applied to the entire 5.4 acre, 100-000 ton wood chip pile. Fifth, both the annual and the individual 24-hour deposition amounts were used to predict the amount of coal particles that would be deposited on the chip pile during the 50-day cycle for chip use stated by Willamette.

The results of the computer modelling show that the total annual deposition will be 3,757 grams. Since these particles are distributed over the entire chip pile, the potential contamination is approximately 27 times less than claimed in the Willamette statement. Based on the annual average deposition, the amount of coal particles deposited on the entire chip pile during the 50-day chip use cycle would be 514.7 grams. Again the potential contamination is approximately 27 times less than claimed by the Willamette statement In addition to the annual average, individual 50-day rolling deposition amounts were calculated. This analysis shows that the highest deposition amount during any 50-day period would be 793 grams. Even in this worst case the potential contamination is 18 times less than claimed in the Willamette statement. If the remainder of the Willamette statement is assume to be accurate, the potential contamination from coal particles in the wood chip pile would be 0.22 mm^2/m^2 average and 0.37 mm^2/m^2 maximum, not 6.07 mm^2/m^2 as claimed by Willamette.

A complete discussion of the modeling methodology and results are presented in the following paragraphs.

Methodology

Meteorology

The Evansville, IN surface station and the Salem, IL upper air meteorological data was selected for use in the ISC-ST modelling. The year of meteorology selected was based on CRSTER modelling conducted for the PSD analysis. In that analysis, CRSTER results indicated that for the years 1970-1974, days with unfavorable meteorology would occur most frequently in the year 1973; therefore the ISC-ST analyses were conducted using year 1973 meteorology.

Emission Sources

All coal handling and storage facilities identified in the Hancock PSD analysis were input into the model. This included 15 sources as shown in Table 1.

Preliminary Modeling

To identify the input parameters that would predict the highest depositions at the chip pile, several preliminary computer runs were performed. A line of 17 receptors from the inactive coal pile to the wood chip pile was modeled. This allowed a concentration and deposition gradient to be generated from the inactive coal pile to the chip pile. To see how deposition varied laterally, a line of 5 receptors was created on a line running across the Willamette property. This line of receptors intersects the line of 17 receptors.

Computer runs were made using a full year of meteorological data and previously described input in the following manner:

a. Runs were conducted for the 17 receptors from the inactive coal pile to the chip pile. These runs utilized the seven particle-size distribution parameters, as listed in Table 2 to this report. These runs were used to estimate particulate concentrations and dry deposition from the 15 Hancock fugitive sources.

b. Runs were also conducted using the same receptor configuration as in (a). However, in these runs, a single particle-size distribution (22 microns), a single gravitational settling velocity, and a single surface reflection coefficient was used. These parameters were the same as those used in the Hancock PSD fugitive dust analysis.

c. Computer runs were also conducted with the same receptor configuration and single particle size deposition parameters as in (a) and (b) above, but with the settling velocity computed in the Willamette report. This settling velocity, computed by the Stoke's Law equation as 1.622 cm/sec., was input to these runs as settling velocity to estimate particulate concentrations and dry depositions.

d. Runs were also made using a single line of five receptors located across the south side of Willamette Industries' property facing the Hancock site. This line of receptors was designed specifically to look at the lateral dispersion of the estimated particulate depositions and dry concentrations from the Hancock fugitive coal dust sources. For these runs, deposition parameters were the same single particle size input as the original PSD fugitive dust study, (i.e., 22 micron particle size, 5.0 cm/sec. deposition velocity).

The modelling results revealed that the predicted deposition rates over the Willamette Industries chip pile would be insignificant. Moreover, a comparison of the modelling results revealed that even when particle size and settling velocity input parameters are varied slightly, the deposition values are somewhat similar. Deposition rates for the 17 receptors using a single particle size of 22 microns and Willamette Industries' computed settling velocity of 1.622 cm/sec were slightly higher than the rates predicted using the 7 particle size distribution. However, the 22 micron particle size and a settling velocity of 5 cm/sec produced the highest deposition value at the chip pile, and consistent with general U.S. EPA criteria for determining worst case, these parameters were used in the analysis.

Impacted Area

To ensure that the total deposition would be calculated, the entire area (5.4 acres) of the 100,000 ton wood chip was used. The ISC-ST model predicts deposition in units of grams/square meter. The model values were multiplied by the area of the chip pile (21,853.8 m^2).

Deposition During 50-Day Cycle

As stated in the Willamette report, the wood chip pile is cycled approximately every 50 days and the amount of coal particles deposited on the pile during that period is the relevant value to estimate potential contamination. Two methods were used to determine this value. First, the total annual amount was averaged over the 7.3 50-day periods in a year. Second, 50-day rolling totals were determined. In this calculation, beginning with the first day of the year, the first fifty 24-hr values are totalled and the value recorded. In the next step the first value is subtracted and the fifty-first value is added and the new total recorded. This process is repeated throughout the year to identify the highest 50-day value that could occur.

Conclusions

The ISC-ST results indicate that even the worst case annual deposition prediction would result in only a slight increase above the existing ambient background pulp contamination level and, therefore, would have little or no effect on the bleached pulp operation.

Moreover, the ISC-ST results indicate that Willamette's method of estimating coal dust deposition over their chip pile resulted an over-estimation of 27 times if their results are compared with the ISC-ST deposition value results.

Furthermore, ISC-ST modelling results revealed that use of a single particle size of 22 microns resulted in slightly higher predicted depositions than the more realistic range of 7 particle sizes based on coal samples. Moreover, results also indicated that when Willamette's settling velocity (1.622 cm/sec) was used in the model the predicted deposition over the chip pile was slightly lower than when the EPA's settling velocity (5 cm/sec) was used.

References

1. Industrial Source Complex (ISC) Dispersion Model, USER's Guide, Volume I, EPA-450/4-79-030 and Volume II, EPA-450/4-79-031, as amended, both dated December 1979.
2. Survey of Fugitive Dust from Coal Mines, PEDCo 1978, EPA-908/1-78-003, dated February 1978.
3. Meteorology and Atomic Energy by David H. Slade, July 1968.
4. Handbook of Engineering Fundamentals by Ovid W. Eschbach and Mott Souders, Third Edition, 1975.
5. Air Quality Criteria for Particulate Matter and Sulfur Oxides, Volume II (Draft), U.S. Environmental Protection Agency, April 1980.

TABLE 1

COAL HANDLING AND STORAGE FACILITIES

HANCOCK POWER PLANT

Source Name
Barge Unloader
Transfer House #1
Coal Stockout
Transfer House #2
Coal Silos
Coal Reclaim
Transfer House #3
Crusher House
Crusher Surge Bins
Emergency Coal Discharge
Transfer House #4
Conveyor Room Pt. #1
Conveyor Room Pt. #2
Coal Stockout Pile
Inactive Coal Pile

TABLE 2

REPRESENTATIVE SIZE DISTRIBUTION FOR COAL DUST

PARTICLE SIZE CATEGORY (μ)	MASS MEAN DIAMETER (μ)	MASS FRACTION (ϕn)	SETTLING VELOCITY (m/sec)	REFLECTION COEFFICIENT (γ_n)
0-9	5.67	0.10	0.001	1.00
9-14	11.68	0.20	0.005	0.84
14-18	16.08	0.20	0.010	0.77
18-29	23.92	0.20	0.023	0.70
29-36	32.63	0.10	0.043	0.64
36-43	39.60	0.10	0.063	0.58
43-50	46.59	0.10	0.087	0.53

Notes: 1. Mass distribution is composite from page 56 of PEDCo '78: Survey of Fugitive Dust from Coal Mines.

2. Settling Velocity and Reflection Coefficient calculated according to equations and graph from ISC User's Guide.

SUPPLEMENT C

NAI'S FUGITIVE EMISSIONS IMPACT ANALYSIS

NAI's FUGITIVE EMISSIONS IMPACT ANALYSIS

I. INTRODUCTION.

A computer modeling study of the impact of the inactive coal pile at Kentucky Utilities proposed Handcock County Generating Station was performed by Normandeau Associates, Inc. (NAI) as a part of the third party ENvironmental impact Statement (EIS) being prepared by NAI for Environmental Protection Agency (EPA) Region IV. This is the report of the modeling results using the Industrial Source Complex (ISC) model.

II. MODEL INPUT.

Figure 1 is a map of the area modeled showing the coal pile, the wood chip pile, and two stations where local meteorology was recorded.

Source

The source is the inactive coal pile shown in Figure 1. The size of the source is 21.5 acres. The emissions from the source are a function of the wind velocity (see Survey of Fugitive Dust from Coal Mines, EPA- 908/1-78-003, Table 5-1, p. 63):

$$Q = 1.6\ U \qquad \text{(II-1)}$$

for Q = emissions in lbs/ (acre/hour)

U = wind speed in meters/sec

Emission height = 15.24 meters.

The coal dust parameters based on Figure 4-2, p. 46 of the above reference and a specific gravity of 1.35 (see The Coal Miner's Pocket Book, 12th Edition, McGraw Hill, 1928, Western Kentucky Coal, Peabody seams #9, #11, #13, and Island Creek Western Kentucky Operation) are:

Diameter (microns)	Mass Mean Dia. (microns)	% by Wt	Fall Velocity (m/sec)
3.08 - 12.33	8.54	5.8	0.003
12.33 - 24.60	19.16	16.56	0.0155
24.60 - 49.33	39.85	78.37	0.0644

The reflection coefficient for each size category is 0.

Receptor

The receptor is the wood chip pile located 2421 meters to the NNW of the source.

Meteorology

The meteorology used in the modeling was from meteorology station SAROAD #1580007 operated by Kenvirons, Inc. for Willamette Industries. Another local meteorology station, SAROAD #1580009, was operated over nearly the same period by Texas Instruments Ecological Services (now NAI). Site # 1580007 was selected for modeling because it was closer to the coal pile and considered to be more representative of the wind field at the coal pile (see Figures 1, 2, and 3). Modeling done previously for PSD permiting used meteorology from Evansville, Indiana (see Figure 4). The Evansville windrose differs significantly from the site 1580007 windrose in the south and southeast wind sectors. The wind at site 1580009 indicates the most frequent winds are from 190 to 230 degrees, which is toward the wood chip pile; however, the critical direction from the coal pile to the wood chip pile is 130 to 150 degrees. That wind flow direction is blocked at the 1580009 site by Jeffry Cliff (see Figure 1).

Meteorology recorded daily at site 1580007 on strip chart was digitized for every other day for the period February 1979 thru January 1980, by Kenvirons. From this sample of the site meteorology, the wind was found to blow from the coal pile to the wood chip pile (130 to 150 degrees) a total of 550 hours, with 342 hours being in the 140-degree direction that has the greatest impact on the wood chip pile. Only the wind speed and direction recorded during those 550 hours were input to the ISC model. Neutral (D) stability was assumed for all hours because there was no record of local stability parameters during the period.

III. MODEL RESULTS - Coal dust deposition.

The results of the modeling by NAI are presented in Table I. The total annual predicted coal dust fall in the wood chip pile is 67,659.7 grams. Reports to EPA Region IV, from Willamette Industries (letter dated May 29, 1981) and Kentucky Utilities Company (letter dated July 10, 1981) also estimated the coal dust impact of the proposed power plant operation on the paper plant operation. The results reported in each document differ significantly because, in all three cases, different methodology was used to calculate impact. The important differences in methodologies were:

Source	Computer Model	Meteorology	Emission Factor
WI	not used	Local	Not calculated
KU	ISC model	Evansville, In	Not a function of wind speed. 50% control
NAI	ISC Model	Local	A function of wind speed. No controls

The KU and NAI modeling further differed in that only the inactive coal pile source was considered by NAI. while KU modeled a total of 15 sources, the largest of which was the inactive coal pile. The large difference in the estimated coal dust deposition predicted by the ISC model run by NAI and KU (67,659.5 vs. 3,757 grams annual total deposition) is for the most part due to the differences between the local meteorology used by NAI and the Evansville meteorology used by KU. Winds in the critical 130 to 150 degree sector are reported by Evansville about 7% of the time and by local meteorology about 15% of the time. The Willamette analysis did not employ computer modeling of the coal dust emissions, but used local meteorology to estimate the number of days per year that the wood chip pile would receive contamination from the coal storage area and based impact on various levels of assumed concentrations of coal dust.

IV. THE IMPACT.

Wood chips are removed from the wood chip pile daily in a pie-shaped section reaching from the bottom to the top of the pile. It takes an average of 50 days to use all 100,000 tons of wood chips. Therefore, on any given day the wood chips entering the plant process include coal dust that was deposited during the last 50 days. The important deposition value is the running 50-day average coal dust deposition. To calculate this average, it was assumed that the meteorological sampling period (Feb 1, 1979 - Jan 31, 1980) was a typical year. The daily deposition values for the year were formed into a circular list. The total deposition was summed over each 50-day period, and a running 50-day average for each day was calculated by dividing by 25. The sum was divided by 25 instead of 50 because the meteorology sample was every other day instead of every day. The area over which deposition occurs is 5.4 acres or 21853.8 square meters. The running 50-day average depositions for the year are presented in Table 1. The total annual deposition is 67659.5 grams. The average daily deposition is 185.4 grams, and the maximum 50 day average value is 485.5 grams.

The impact of the coal dust falling on the wood chip pile is determined by the effect of the dust on the paper pulp mat that is the final product of the pulp plant. The test procedure for pulp quality is to count visible dirt on samples of the mat at regular intervals.

The amount of dirt is determined by comparing the observed dirt to a size standard (see Figure 5) and summing the total area of all visible dirt. The procedure in use at the Willamette plant involves wetting the sample mat so that subsurface dirt can be counted.

The visible dirt count standards (see Figure 5) for the pulp product are:

0.0 - 3	Number One Prime
3.1 - 6.0	Number Two Prime
Greater than 6	Off Grade

The pulp product may also be degraded by being off color. The plant has experienced degradation of the pulp due to contamination from a fire in the wood chip pile. A large number of particles in the pulp that are too fine to be seen can cause a gray tint (degrading brightness) in the product that makes it unsuitable for high quality white paper production.

The calculations used to determine pulp grade degradation due to coal dust in the wood chip pile are detailed in Section VII. It was assumed that: (1) the average visible particle is 0.02 square milimeters in cross section; (2) the removal efficiency of the the plant cleaning equipment is 85% for coal dust; (3) 1% of the emitted coal particles are in the visible range (diameter 0.02 millimeters or larger).

Assumption (1) is based on Figure 5. Assumption (2) is based on the letter from Willamette cited above. Assumption (3) is based on the EPA document Survey of Fugitive Dust from Coal Mines, Figure 4 - 2.

One gram per day of visible particulate in the final pulp product will produce a dirt count of 0.026 (see Section VII) on that day. However, not all the dust that falls in the wood chip pile appears in the final pulp mat in the form of countable dirt particles. The reducing factors are the percent visible emissions (1%) and percent of the particles that plant process cleaning devices fail to remove (15%). This gives a reduction factor:

$$R = 0.15 \times 0.01 = 0.0015 \qquad \text{(IV-1)}$$

The final dirt count is given by:

$$DC = (0.026 \times R \times CD) + ADC \qquad \text{(IV-2)}$$

Where:

CD is coal dust deposited in the wood pile in grams.

DC is the dirt count measured in square millimeters per square meter.

ADC is the average background dirt count = 1.94.

The coal dust deposition required to achieve a dirt count of 3.1 in the pulp product is (from eq IV-2):

$$\begin{aligned} CD &= (DC - ADC)/(0.026 \times R) \\ &= (3.1 - 1.94)/0.000039 \\ &= 29{,}744 \text{ grams} \end{aligned}$$

The maximum deposition predicted by the model was 485.5 grams. The model does not demonstrate any impact from the coal storage piles with respect to visible coal dust emissions.

Equation IV-2 does not take into account possible reduction in brightness of the product due to the subvisible particles that fall on the wood chip and are carried through the process to the mat. There is no method of quantifying the loss of brightness due to these particles. It is possible to count the number of visible particles and the area of particles in the subvisible range that are present in the mat for each gram of coal dust deposited on the wood chip pile.

The size distribution curve in the EPA document referenced above states that the median diameter of particles from the coal storage pile is 20 microns. Each 20-micron particle would have a cross-sectional area of 3.1416 x 10^{-6} square meters. There will be 55.556 square millimeters of surface obscured by each gram of coal dust. A subvisible soil ratio (SSR) can be defined as the ratio of the area occupied by subvisible particles relative to the surface area of the mat. The SSR is computed in a manner similar to the dirt count calculation given above. For each gram of subvisible coal dust in the pulp mat, the SSR is 0.013411 (sq mm/sq m). See Section VII for the calculations for subvisible particles.

The reduction factor for subvisible particles is:

$$RSV = 0.15 \times 0.99 = 0.1485 \qquad (IV-3)$$

The subvisible soil ratio is:

$$SSR = 0.000208 \times RSV \times CD \qquad (IV-4)$$

V. UNCERTAINTIES.

The ISC model used in this study is a member of the class of models known as Gaussian plume models. Ideal conditions for application of the Gaussian models are: 1) steady state emmissions; 2) flat to gently rolling terrain; 3) local meteorology for a period of several years. When these conditions are met, the Gaussian models are able to predict long-term (seasonal or annual average) concentrations within a factor of two accuracy. The model predictions in this study cannot be considered accurate to within a factor of two because of uncertainties in all three conditions.

The emissions from the coal pile were modeled on the basis of hourly variations in wind speed in accordance with equation II-1. The emission factor does not consider that emissions would be less during periods of rain nor that are emissions increased for periods when the coal pile is being disturbed. The EPA source for the emission factor suggests that the emissions are known to a factor of two at best when only the variations due to sampling techniques are considered.

Local meteorology for a single year was used in this study. The meteorology for the period used may not be representitive of the meteorology that will be encountered over the life of the proposed plant site. The terrain at the site is complex. It is evident from the patterns of meteorology at the two local sampling stations that the complex terrain channels the wind flow near the ground. No single meteorology station can adequately represent wind flows in a complex terrain situation. Because of limitations in the meteorology data taken locally, hourly stability values could not be developed.

Based on the lack of specific knowledge of so many factors, the modeling results should be considered good to an order of magnitude factor only.

VI. CONCLUSION.

The conclusion of this study is that within the stat-of-the-art for modeling technology and the limits of data on emissions and site meteorology, the potential cannot be demonstrated for impact on the paper plant operation from visible coal particles. It was not possible to calculate the potential impact of subvisible particles on pulp plant operations.

VII. CALCULATIONS.

Visible Particle Characteristics:

Area = A = 0.02 x 10-6 $_{m2}$

Diameter = D = 2(A/pi)$^{.5}$= 160 x 10^{-6} m

Radius = R = D/2 = 80 x 10-6 m

Density = 1.35 x 10^{6} g/m^{3}

Volume = 4/3 x pi R^{3} = 2.13 x 10^{12} m^{3}

Weight = Volume x Density = 2.87 x 10-6 grams

# Particles per gram = P = 348,142.82

Area obscured by 1 gram of dust in the pulp

P x A = 0.02 x 348,142.82 = 6,962.86 mm^{2}

Daily pulp production in square meters of mat = 4,142.62 m2

(Ref Willamette Letter cited above)

2000 ft^{2} x 0.9290304 m^{2}/ft^{2} x 1440 min/day = 267,561 m^{2}/day

Visible Dirt Count per Gram of Visible Coal Dust in the Pulp Mat

6962.86 / 267561 = 0.026

Subvisible Particle Characteristics:

Diameter = 20 x 10-6 m

Cross sectional Area = A = pi x $(D/2)^2$ = 3.1416 x 10^{-10} m^2

Volume = (4/3) x pi x $(D/2)^3$ = 4.1888 x 10^{-15} m^3

Weight = Density x Volume = 5.649 x 10^{-9} grams

# particles per gram = 1.7684 x 10^8

Area covered by 1 gram of subvisible particles

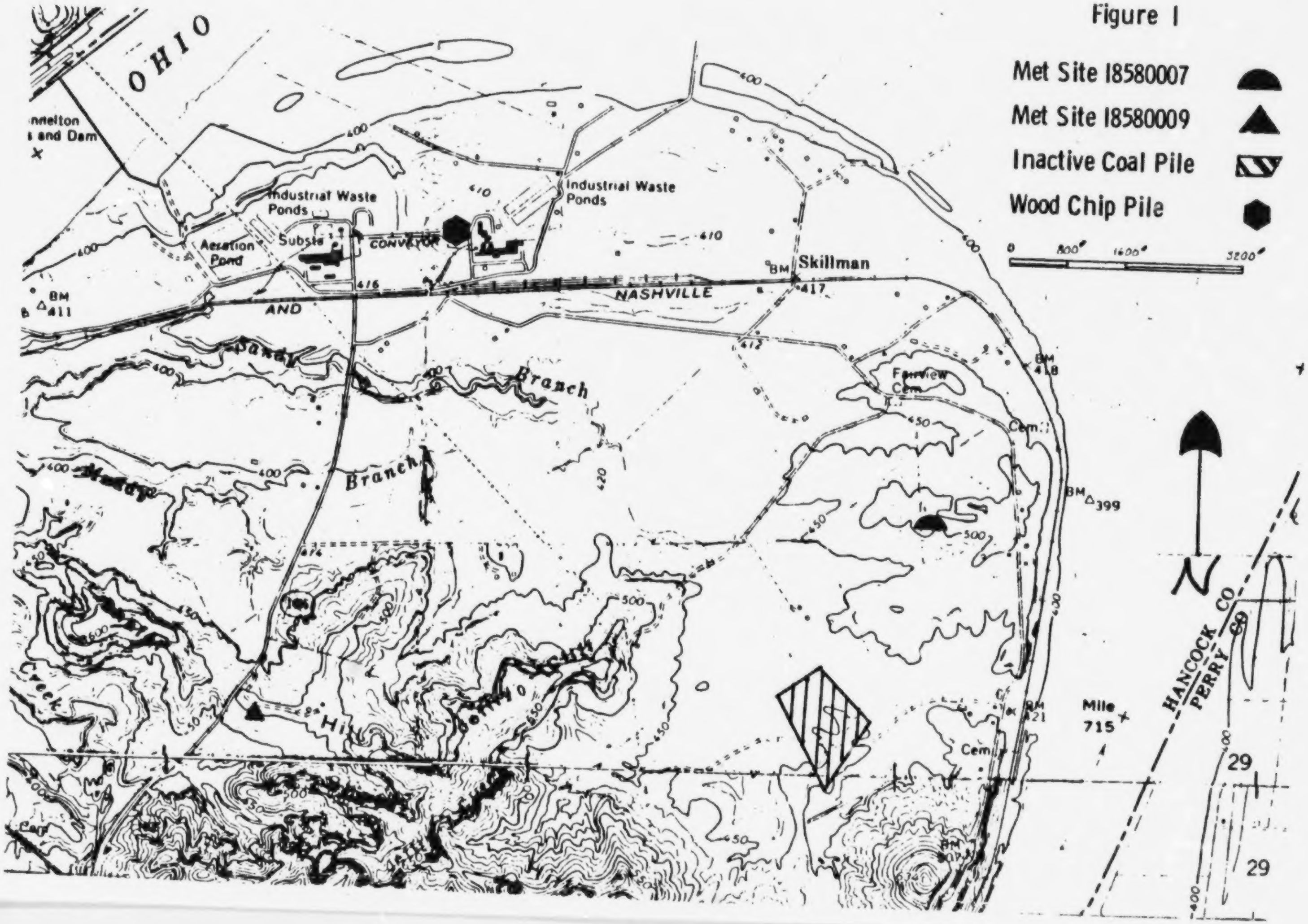
1.7684 x 10^8 x A = 55.556 mm^2

Subvisible Soil Ratio = Area Obscured by Particles/Mat Product

55.556/267561 = 0.000208 sq mm/sq m

per day per gram of subvisible coal in the pulp mat.

Figure I


Met Site 18580007 ◓
Met Site 18580009 ▲
Inactive Coal Pile ▨
Wood Chip Pile ⬢
0
800'
1600'
3200'
N
OHIO
Industrial Waste Ponds
Industrial Waste Ponds
Aeration Pond
Substa
CONVEYOR
Skillman
NASHVILLE
AND
BM 411
BM 417
BM 418
BM 399
BM 421
Fairview Cem
Cem
Cem
Sandy Branch
Muddy Branch
Creek
Hill
Mile 715
HANCOCK CO
PERRY CO
29
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400
410
412
416
420
450
500

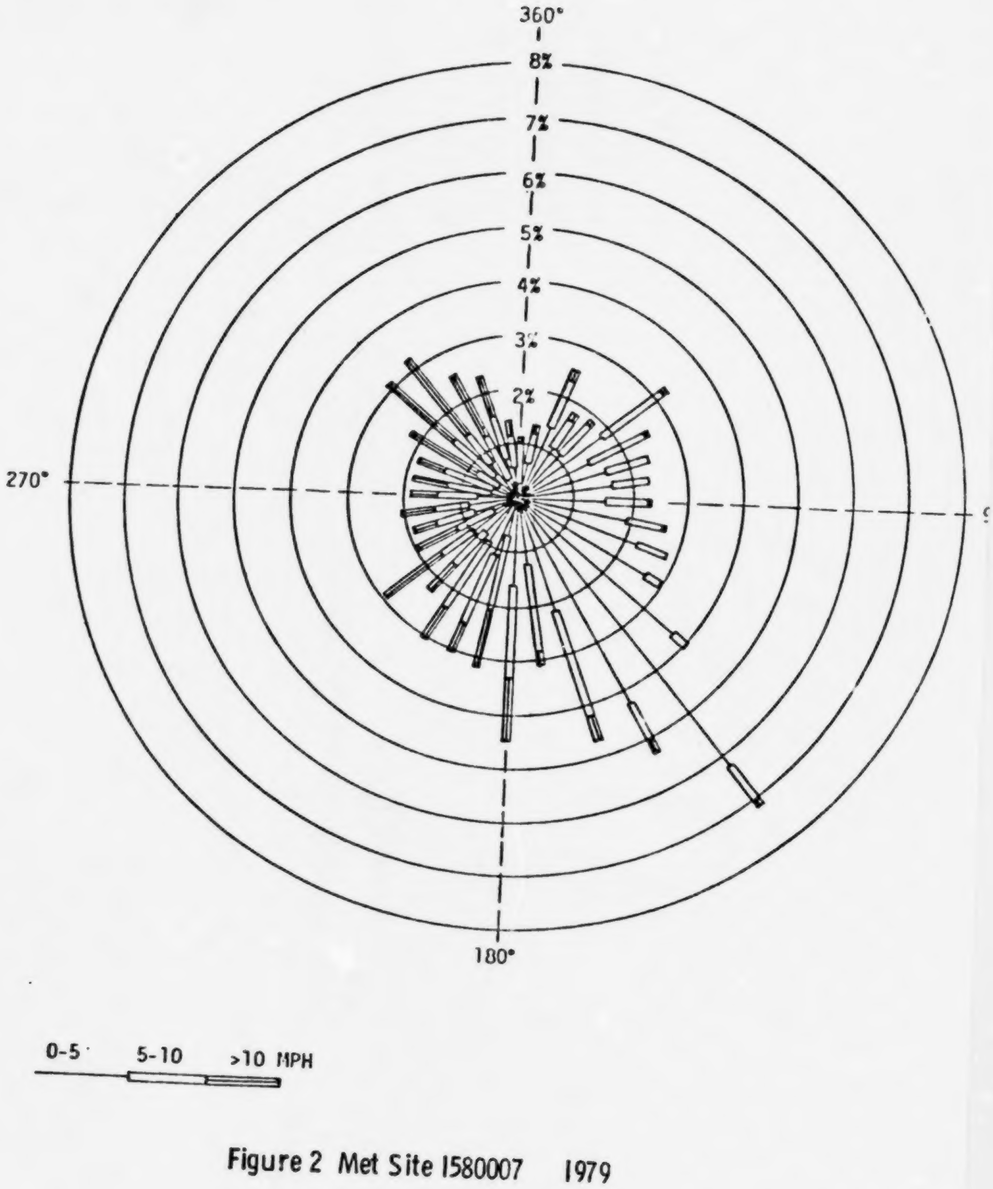


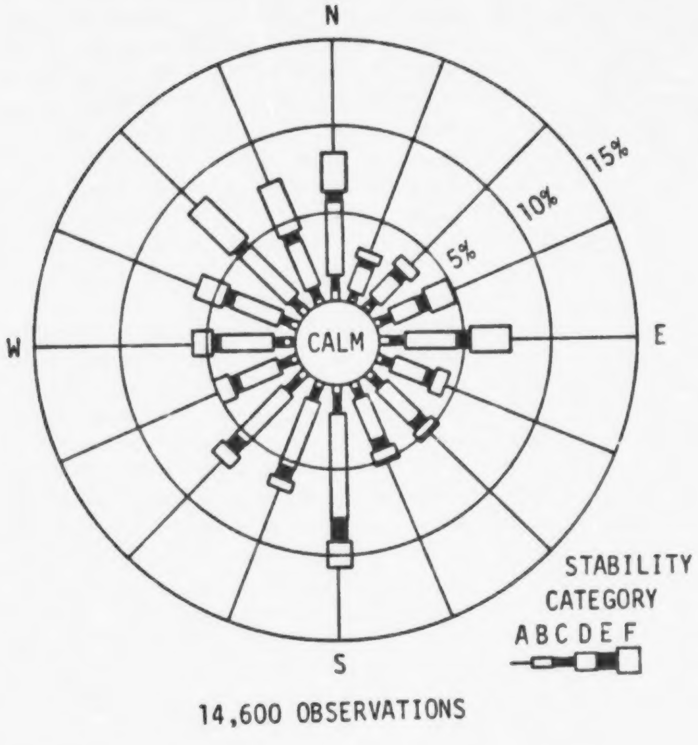
Figure 2 Met Site 1580007 1979

MONTHLY WIND DIRECTION FREQUENCY DISTRIBUTION

HANCOCK COUNTY SITE #181580009J02 JULY 1979 - JUNE 1980

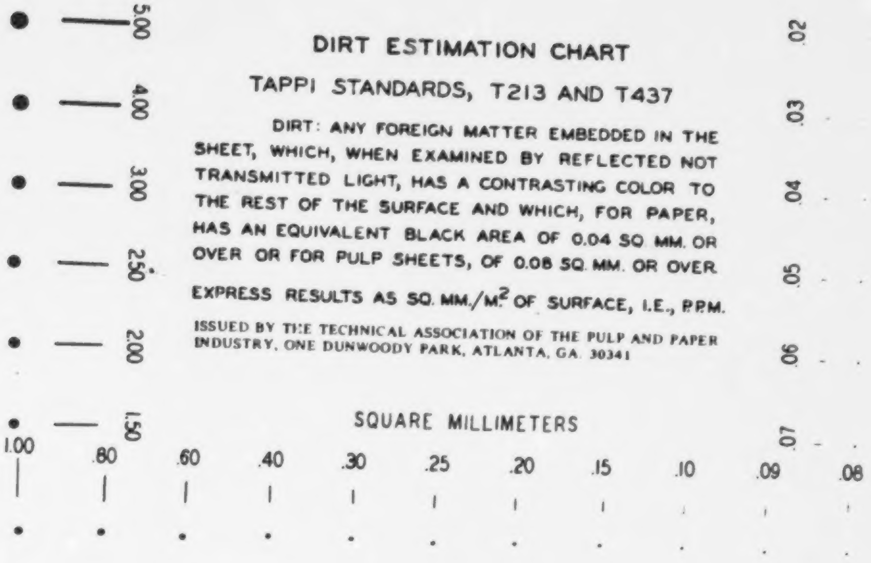
Wind Direc-tion Degrees	MONTH												ANNUAL TOTAL
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
0-10	27	7	12	17	24	13	3	21	36	9	13	16	198
10-20	28	16	13	10	17	22	11	15	39	11	4	11	197
20-30	37	10	23	15	19	25	21	20	52	2	10	12	246
30-40	41	12	18	24	26	31	37	18	52	7	19	10	295
40-50	36	16	13	28	30	31	15	20	57	4	19	15	284
50-60	22	24	24	41	25	36	23	19	47	3	25	23	312
60-70	24	23	60	22	34	37	19	13	35	13	10	7	317
70-80	13	8	20	28	23	33	26	6	25	5	10	8	205
80-90	4	8	10	20	7	26	37	3	23	9	2	5	154
90-100	6	5	6	23	5	8	41	2	11	9	7	8	131
100-110	6	6	8	5	3	6	27	5	10	4	16	3	99
110-120	4	4	6	16	3	10	21	3	9	6	7	3	92
120-130	6	9	14	23	5	5	12	4	3	6	6	1	94
130-140	7	12	18	13	7	4	4	2	5	7	3	2	84
140-150	8	11	12	5	5	10	0	1	11	4	7	2	76
150-160	9	27	14	5	5	14	4	2	7	10	9	3	109
160-170	10	25	22	3	12	11	9	14	17	18	10	6	157
170-180	13	33	14	3	4	10	11	15	8	14	11	5	141
180-190	13	29	45	2	9	7	16	38	21	34	34	52	300
190-200	32	37	48	10	25	12	19	57	26	61	42	51	420
200-210	33	22	56	3	25	21	20	66	37	86	63	64	496
210-220	22	19	35	9	59	54	21	64	45	83	72	98	581
220-230	14	18	12	20	89	92	24	42	24	80	48	39	502
230-240	7	20	15	33	66	74	16	21	16	37	33	29	365
240-250	8	13	10	29	31	22	7	13	6	34	23	23	219
250-260	3	14	20	29	14	20	5	9	3	30	23	10	180
260-270	17	26	16	17	17	13	5	14	5	19	20	6	175
270-280	28	17	21	14	7	7	6	9	3	19	21	6	158
280-290	20	20	11	24	9	9	9	7	5	14	23	9	160
290-300	17	26	14	16	9	6	7	5	1	6	20	8	135
300-310	16	21	20	17	12	1	6	4	1	15	12	7	132
310-320	13	31	19	18	12	2	6	5	6	8	16	17	153
320-330	23	26	25	18	13	3	4	5	7	10	19	15	168
330-340	38	28	27	10	19	10	1	6	12	13	15	25	204
340-350	57	34	29	21	10	5	5	12	18	14	25	36	266
350-360	45	13	10	31	18	17	1	30	14	19	20	23	241

Figure 3 Met Site 1580009



SOURCE: National Climatic Center (1975)

Figure 4 Met Site Evansville, Indiana 1970-74



DIRT ESTIMATION CHART

TAPPI STANDARDS, T213 AND T437

DIRT: ANY FOREIGN MATTER EMBEDDED IN THE SHEET, WHICH, WHEN EXAMINED BY REFLECTED NOT TRANSMITTED LIGHT, HAS A CONTRASTING COLOR TO THE REST OF THE SURFACE AND WHICH, FOR PAPER, HAS AN EQUIVALENT BLACK AREA OF 0.04 SQ. MM. OR OVER OR FOR PULP SHEETS, OF 0.08 SQ. MM. OR OVER.

EXPRESS RESULTS AS SQ. MM./M.^{2} OF SURFACE, I.E., P.P.M.

ISSUED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY, ONE DUNWOODY PARK, ATLANTA, GA. 30341

SQUARE MILLIMETERS

5.00
4.00
3.00
2.50
2.00
1.50
1.00
.80
.60
.40
.30
.25
.20
.15
.10
.09
.08
.07
.06
.05
.04
.03
.02

Figure 5 Dirt Estimation Chart

Table I. Coal Dust Deposition

JULIAN DAY	ISC MODEL DEPOSITION RATE (G/SQ M)	50 DAY RUNNING AVE RATE (G/SQ M)	WOOD CHIP PILE 50 DAY RUNNING AVERAGE DEPOSITION (Grams)
1		0.0071	155.51
2		0.0071	155.51
3		0.0071	155.51
4		0.0071	155.51
5		0.0071	155.51
6	0.1679	0.0071	155.51
7		0.0138	302.28
8		0.0123	268.45
9		0.0123	268.45
10	0.0456	0.0109	239.08
11		0.0128	278.94
12		0.0115	250.88
13		0.0115	250.88
14		0.0115	250.88
15		0.0115	250.88
16	0.0588	0.0115	250.88
17		0.0138	302.28
18		0.0138	302.28
19		0.0138	302.28
20		0.0138	302.28
21		0.0138	302.28
22		0.0138	302.28
23		0.0138	302.28
24		0.0136	297.91
25		0.0136	297.91
26		0.0136	297.91
27		0.0136	297.91
28		0.0136	297.91
29		0.0136	297.91
30		0.0132	289.34
31		0.0132	289.34
32		0.0132	289.34
33	0.0508	0.0132	289.34
34		0.0153	333.75
35		0.0153	333.75
36		0.0150	327.11
37		0.0150	327.11
38		0.0150	327.11
39	0.0105	0.0150	327.11
40		0.0154	336.29
41	0.0299	0.0154	336.29
42		0.0166	362.42
43		0.0166	362.42
44		0.0145	317.75
45	0.0046	0.0145	317.75

TABLE 1 - Continued

JULIAN DAY	ISC MODEL DEPOSITION RATE (G/SQ M)	50 DAY RUNNING AVE RATE (G/SQ M)	WOOD CHIP PILE 50 DAY RUNNING AVERAGE DEPOSITION (Grams)
46		0.0147	321.78
47		0.0147	321.78
48		0.0147	321.78
49		0.0147	321.78
50		0.0147	321.78
51	0.1203	0.0147	321.78
52		0.0195	426.94
53	0.0670	0.0195	426.94
54		0.0222	485.50
55		0.0222	485.50
56		0.0222	485.50
57		0.0222	485.50
58		0.0155	338.73
59	0.0026	0.0155	338.73
60		0.0156	341.01
61		0.0156	341.01
62		0.0138	301.15
63		0.0138	301.15
64		0.0138	301.15
65		0.0138	301.15
66		0.0138	301.15
67		0.0138	301.15
68		0.0114	249.75
69		0.0114	249.75
70		0.0114	249.75
71		0.0114	249.75
72		0.0114	249.75
73		0.0114	249.75
74		0.0114	249.75
75	0.0400	0.0114	249.75
76		0.0130	284.71
77	0.1170	0.0130	284.71
78		0.0177	386.99
79		0.0177	386.99
80		0.0177	386.99
81		0.0177	386.99
82		0.0177	386.99
83		0.0177	386.99
84		0.0177	386.99
85		0.0157	342.58
86		0.0157	342.58
87	0.0036	0.0157	342.58
88		0.0158	345.73
89		0.0158	345.73
90		0.0158	345.73

TABLE I - Continued

JULIAN DAY	ISC MODEL DEPOSITION RATE (G/SQ M)	50 DAY RUNNING AVE RATE (G/SQ M)	WOOD CHIP PILE 50 DAY RUNNING AVERAGE DEPOSITION (Grams)
91		0.0154	336.55
92		0.0154	336.55
93		0.0142	310.41
94		0.0142	310.41
95		0.0142	310.41
96		0.0142	310.41
97	0.0355	0.0140	306.39
98		0.0154	337.42
99		0.0154	337.42
100		0.0154	337.42
101		0.0154	337.42
102		0.0154	337.42
103		0.0106	232.26
104		0.0106	232.26
105		0.0079	173.69
106		0.0079	173.69
107		0.0079	173.69
108		0.0079	173.69
109		0.0079	173.69
110		0.0079	173.69
111	0.0055	0.0078	171.42
112		0.0081	176.23
113	0.0168	0.0081	176.23
114		0.0087	190.91
115	0.0192	0.0087	190.91
116		0.0095	207.70
117		0.0095	207.70
118		0.0095	207.70
119	0.0114	0.0095	207.70
120		0.0100	217.66
121		0.0100	217.66
122		0.0100	217.66
123		0.0100	217.66
124		0.0100	217.66
125		0.0100	217.66
126		0.0100	217.66
127		0.0084	182.70
128		0.0084	182.70
129	0.0979	0.0037	80.42
130		0.0076	166.00
131	0.0064	0.0076	166.00
132		0.0079	171.55
133		0.0079	171.55
134		0.0079	171.55
135		0.0079	171.55

TABLE I - Continued

JULIAN DAY	ISC MODEL DEPOSITION RATE (G/SQ M)	50 DAY RUNNING AVE RATE (G/SQ M)	WOOD CHIP PILE 50 DAY RUNNING AVERAGE DEPOSITION (Grams)
136		0.0079	171.55
137		0.0079	171.55
138		0.0079	171.55
139	0.0242	0.0077	168.41
140		0.0087	189.56
141		0.0087	189.56
142		0.0087	189.56
143		0.0087	189.56
144		0.0087	189.56
145		0.0087	189.56
146		0.0087	189.56
147		0.0087	189.56
148		0.0087	189.56
149	0.0085	0.0073	158.53
150		0.0076	165.96
151		0.0076	165.96
152		0.0076	165.96
153		0.0076	165.96
154		0.0076	165.96
155	0.0146	0.0076	165.96
156		0.0082	178.72
157		0.0082	178.72
158		0.0082	178.72
159		0.0082	178.72
160		0.0082	178.72
161		0.0082	178.72
162		0.0082	178.72
163	0.0095	0.0080	173.91
164		0.0083	182.22
165	0.0063	0.0077	167.53
166		0.0079	173.04
167		0.0072	156.25
168		0.0072	156.25
169		0.0072	156.25
170		0.0072	156.25
171	0.0081	0.0067	146.29
172		0.0070	153.37
173		0.0070	153.37
174		0.0070	153.37
175		0.0070	153.37
176		0.0070	153.37
177		0.0070	153.37
178		0.0070	153.37
179	0.0202	0.0070	153.37
180		0.0078	171.03

TABLE 1 - Continued

JULIAN DAY	ISC MODEL DEPOSITION RATE (G/SQ M)	50 DAY RUNNING AVE RATE (G/SQ M)	WOOD CHIP PILE 50 DAY RUNNING AVERAGE DEPOSITION (Grams)
181		0.0039	85.45
182		0.0039	85.45
183		0.0037	79.90
184		0.0037	79.90
185		0.0037	79.90
186		0.0037	79.90
187		0.0037	79.90
188		0.0037	79.90
189		0.0037	79.90
190		0.0037	79.90
191		0.0027	58.74
192		0.0027	58.74
193		0.0027	58.74
194		0.0027	58.74
195		0.0027	58.74
196		0.0027	58.74
197		0.0027	58.74
198		0.0027	58.74
199		0.0027	58.74
200		0.0027	58.74
201		0.0023	51.31
202		0.0023	51.31
203		0.0023	51.31
204		0.0023	51.31
205		0.0023	51.31
206		0.0023	51.31
207		0.0018	38.55
208		0.0018	38.55
209		0.0018	38.55
210		0.0018	38.55
211		0.0018	38.55
212		0.0018	38.55
213		0.0018	38.55
214		0.0018	38.55
215		0.0014	30.25
216		0.0014	30.25
217	0.0031	0.0011	24.74
218		0.0013	27.45
219		0.0013	27.45
220		0.0013	27.45
221	0.0073	0.0013	27.45
222		0.0015	33.83
223		0.0012	26.75
224		0.0012	26.75
225		0.0012	26.75

TABLE 1 Continued

JULIAN DAY	ISC MODEL DEPOSITION RATE (G/SQ M)	50 DAY RUNNING AVE RATE (G/SQ M)	WOOD CHIP PILE 50 DAY RUNNING AVERAGE DEPOSITION (Grams)
226		0.0012	26.75
227		0.0012	26.75
228		0.0012	26.75
229	0.0137	0.0012	26.75
230		0.0018	38.72
231		0.0010	21.07
232		0.0010	21.07
233	0.0420	0.0010	21.07
234		0.0026	57.78
235	0.0130	0.0026	57.78
236		0.0032	69.15
237		0.0032	69.15
238		0.0032	69.15
239	0.0200	0.0032	69.15
240		0.0040	86.63
241	0.0113	0.0040	86.63
242		0.0044	96.51
243		0.0044	96.51
244		0.0044	96.51
245	0.0154	0.0044	96.51
246		0.0050	109.97
247		0.0050	109.97
248		0.0050	109.97
249		0.0050	109.97
250		0.0050	109.97
251		0.0050	109.97
252		0.0050	109.97
253		0.0050	109.97
254		0.0050	109.97
255	0.0131	0.0050	109.97
256		0.0056	121.42
257		0.0056	121.42
258		0.0056	121.42
259		0.0056	121.42
260		0.0056	121.42
261	0.0076	0.0056	121.42
262		0.0059	128.06
263	0.0023	0.0059	128.06
264		0.0060	130.07
265		0.0060	130.07
266		0.0060	130.07
267		0.0060	130.07
268		0.0060	130.07
269		0.0058	127.36
270		0.0058	127.36

TABLE I - Continued

JULIAN DAY	ISC MODEL DEPOSITION RATE (G/SQ M)	50 DAY RUNNING AVE RATE (G/SQ M)	WOOD CHIP PILE 50 DAY RUNNING AVERAGE DEPOSITION (Grams)
271	0.0137	0.0058	127.36
272		0.0064	139.34
273		0.0061	132.96
274		0.0061	132.96
275		0.0061	132.96
276		0.0061	132.96
277		0.0061	132.96
278		0.0061	132.96
279		0.0061	132.96
280		0.0061	132.96
281	0.0150	0.0055	120.98
282		0.0061	134.09
283		0.0061	134.09
284		0.0061	134.09
285		0.0045	97.38
286		0.0045	97.38
287		0.0039	86.02
288		0.0039	86.02
289	0.0140	0.0039	86.02
290		0.0045	98.25
291	0.0195	0.0037	80.77
292		0.0045	97.82
293		0.0040	87.94
294		0.0040	87.94
295		0.0040	87.94
296		0.0040	87.94
297		0.0034	74.48
298		0.0034	74.48
299		0.0034	74.48
300		0.0034	74.48
301		0.0034	74.48
302		0.0034	74.48
303	0.0766	0.0034	74.48
304		0.0065	141.44
305		0.0065	141.44
306		0.0065	141.44
307		0.0059	129.99
308		0.0059	129.99
309		0.0059	129.99
310		0.0059	129.99
311	0.0495	0.0059	129.99
312		0.0079	173.26
313		0.0076	166.61
314		0.0076	166.61
315		0.0075	164.60

TABLE 1 - Continued

JULIAN DAY	ISC MODEL DEPOSITION RATE (G/SQ M)	50 DAY RUNNING AVE RATE (G/SQ M)	WOOD CHIP PILE 50 DAY RUNNING AVERAGE DEPOSITION (Grams)
316		0.0075	164.60
317		0.0075	164.60
318		0.0075	164.60
319		0.0075	164.60
320		0.0075	164.60
321	0.0387	0.0075	164.60
322		0.0091	198.43
323	0.0336	0.0085	186.46
324		0.0099	215.83
325	0.0321	0.0099	215.83
326		0.0112	243.89
327		0.0112	243.89
328		0.0112	243.89
329		0.0112	243.89
330		0.0112	243.89
331		0.0112	243.89
332		0.0112	243.89
333		0.0106	230.78
334		0.0106	230.78
335		0.0106	230.78
336		0.0106	230.78
337	0.0050	0.0106	230.78
338		0.0108	235.15
339		0.0108	235.15
340		0.0108	235.15
341		0.0102	222.91
342		0.0102	222.91
343	0.0098	0.0094	205.86
344		0.0098	214.43
345		0.0098	214.43
346		0.0098	214.43
347		0.0098	214.43
348		0.0098	214.43
349	0.0076	0.0098	214.43
350		0.0101	221.07
351		0.0101	221.07
352		0.0101	221.07
353		0.0101	221.07
354		0.0101	221.07
355		0.0071	154.11
356		0.0071	154.11
357	0.0511	0.0071	154.11
358		0.0091	198.78
359		0.0091	198.78
360		0.0091	198.78
361		0.0091	198.78
362		0.0091	198.78
363		0.0071	155.51
364		0.0071	155.51
365		0.0071	155.51

TABLE I - Continued

TOTAL ANNUAL DEPOSITION 67659.7 Grams

MEAN DAILY DEPOSITION 185.4 Grams

MAXIMUM 50 DAY RUNNING AVERAGE DEPOSITION 485.5 Grams